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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND ALEX. RICHARDSON.

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Copies of Tender forms, Specifications, Drawings and Conditions are available at the charges mentioned hereunder, upon application to :—
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The Commissioners do not bind themselves to accept the lowest or any Tender.
The Specifications and Drawings may be inspected at the Offices of the Consulting Engineers of the Victorian Government, Messrs. JOHN COATES & Co., LTD., Victoria House, Melbourne Place, Strand, London, W.C. 2.
Tenders on prescribed forms, properly endorsed, must be delivered to :—
R. LIDDELOW, Secretary, Electricity Commissioners, 673, Bourke Street West, Melbourne, Victoria, Australia, not later than Noon on 24th February, 1921.
(Signed) PETER McBRIDE, Agent-General for Victoria. K 910

LONDON COUNTY COUNCIL.

Tenders are Invited for the REPAIRING of CARRIAGEWAY of Chelsea Suspension Bridge.
Persons desiring to Tender may obtain the specifications, bills of quantities, Form of Tender &c., on application to the Chief Engineer at the County Hall, Spring Gardens, S.W., upon payment to the Cashier of the Council of the sum of £3. This amount will be returnable only if the tenderer shall have sent in a *bona fide* Tender and shall not have withdrawn the same. Full particulars of the work may be obtained on personal application and the specification and other contract documents may be inspected at the County Hall before payment of the fee. No Tender received after FOUR p.m. on Monday, 20th December, 1920, will be considered.
The Council does not bind itself to accept the lowest or any Tender.
JAMES BIRD, Clerk of the London County Council. L 100

GREAT WESTERN RAILWAY.

The Directors of this Company are prepared to receive

Tenders for Widening the RAILWAY for additional loop lines between Bridgend and Margam.
Plans and Specification may be seen and Forms of Tender and Bills of Quantities obtained at the office of the Engineer at this Station, between the hours of Ten a.m. and Four p.m.
Tenders addressed to the undersigned and marked outside "Tender for Bridgend and Margam Loops" will be received not later than Ten a.m. on Tuesday, the 4th January, 1921.
The Directors do not bind themselves to accept the lowest or any Tender.
A. H. BOLTER, Secy.
Paddington Station, London, 7th December, 1920. L 118

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED, are prepared to receive

Tenders for the Supply of:— LOCOMOTIVE DUPLICATIVE PARTS.
Specifications and forms of Tender may be obtained at the Company's Office, 91 Petty France, Westminster, S.W. 1.
Tenders addressed to the Chairman and Directors of the South Indian Railway Co., Ltd., marked "Tender for Locomotive Duplicative Parts" must be left with the undersigned not later than Two p.m. on Wednesday, the 5th January, 1921.
A charge, which will not be returned, will be made of 20/- for each copy of the Specification. Copies of the drawings may be obtained at the office of ROBERT WHITE, Esq., M.Inst.C.E., Consulting Engineer to the Company, 5, Victoria Street, Westminster, S.W. 1.
By Order, W. B. REYNOLDS, for Managing Director.
91, Petty France, Westminster, S.W. 1. 7th December, 1920. L 141

SIMLA WATERWORKS EXTENSION.

GUMA SCHEME.

CONTRACT No. 3.

The Municipal Committee, Simla, invite

Tenders for Supplying, ERECTING and RUNNING for one month a NEW PUMPING PLANT, consisting of three units and steel rising mains, etc., with all fittings for the water supply. The pump lift (excluding friction) is 3039 feet. The Municipal Committee are also prepared to consider alternative Tenders for other forms of plant to do the duty required by the Specification. Plans may be seen and the Specification, Bill of Particulars and Form of Tender obtained on written enquiry addressed to A. F. HENDERSON, Esq., c/o Messrs. HENRY S. KING & Co., Cornhill, E.C., on payment of £1 only. Tenders which must be on forms provided with Bill of Particulars and Schedule fully priced out, must be sent in sealed cover addressed to the Secretary, Municipal Offices, Simla, and must be received by him before Four p.m. on the 28th March, 1921.
The Municipal Committee do not bind themselves to accept the lowest or any Tender.
Parties tendering do so at their own cost.
A. LANGLEY, President, Municipal Committee.
Dated Simla, the 15th November, 1920. L 112

G. R.

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BY DIRECTION OF THE DISPOSAL BOARD.
(PLANT & MACHINERY SECTION.)

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1,000 No. 1 Transmitters lying at GREENWICH.

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Tons.	c.	q.	lbs.	
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Miles.	yds.		
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	880	,, P. C. Twin 10 pr/10. ,,
16	0	,, 1 pr/20. ,,
213½	0	,, R. & C. C. 7 pr/10. ,,
1	0	,, G. P. No. 14 Quad. la. ,,

Lying at P.O.S.D., Fordrough Lane Birmingham.

Detailed particulars, permits to view, and Tender Forms, which must be completed and returned on or before TEN a.m. on 20th December, can be obtained on application to THE CONTROLLER, D.B.I.E., Plant and Machinery Section, Charing Cross Buildings, W.C. 2. L 116

APPOINTMENTS OPEN.

UNIVERSITY OF LONDON.

The Senate invite

Applications for the CHADWICK (part-time) CHAIR OF MUNICIPAL ENGINEERING tenable at University College. Salary £400 a year. Applications (12 copies) must be received not later than first post on 1st Feb., 1921, by the ACADEMIC REGISTRAR, University of London, South Kensington, S.W. 7, from whom further particulars may be obtained. L 79

VICTORIA JUBILEE TECHNICAL INSTITUTE. (Central Technological Institute, Bombay Presidency). BOMBAY, INDIA.

HEAD OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

Applications are Invited for the POST of HEAD of the DEPARTMENT of MECHANICAL ENGINEERING of the Victoria Jubilee Technical Institute (Central Technological Institute, Bombay Presidency). Engagement renewable every sixth year. Salary will commence at Rs. 700 and rise to Rs. 1,000 per mensem. Further particulars may be obtained from K 987, Offices of ENGINEERING.—Applications should be made so as to reach the undersigned on or before the 18th December, 1920, c/o. Mr. T. S. DAWSON; HENRY S. KING & Co., London.
The selected candidate will be required to obtain a medical certificate of fitness for work from a medical practitioner selected by the Board.
D. H. WACHA, Hon. Secretary of the Board of Trustees.
Victoria Jubilee Technical Institute, (Central Technological Institute) Byculla, Bombay, India. K 987

LOUGHBOROUGH COLLEGE.

H. SCHOFIELD, M.B.E., B.Sc., A.R.C.Sc., A.M.I.C.E., D.I.C., Principal.

Applications are Invited in respect of the following VACANCIES in the WORKS DEPARTMENT of the College :—
Universal Milling,
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Electric Fitting and Switch Gear Assembly.
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Applicants should have served a full apprenticeship and be of good education and address. They should also refer in every case to the particular vacancy for which they desire to offer themselves as candidates.
Applications, together with full particulars and salary required, must be submitted on the official form, which may be obtained from the PRINCIPAL of the College, to whom they must be returned not later than Saturday, December 18th. L 97

The METROPOLITAN ASYLUMS BOARD invite

Applications for the following APPOINTMENTS in the Department of the Engineer-in-Chief, on their Head Office Staff, viz :—
(a) One Engineering Draughtsman (temporary for at least six months with the possibility of extension) to prepare working drawings, specifications and estimates for the installation of Steam Boiler plants, hot water supply and heating installations in connection with large institutions. The salary offered is £180 per annum plus War Bonus at Civil Service rates (at the present time £183 9s. 2d. per annum).
(b) One ENGINEERING DRAUGHTSMAN (Temporary, for at least six months with the possibility of extension) with experience similar to above. The salary offered is £100 per annum, plus War Bonus at Civil Service rates (at the present time £147 13s. 9d. per annum.
(c) One ENGINEERING DRAUGHTSMAN (Temporary, for at least six months with the possibility of extension) to prepare working drawings, specifications and estimates for the installation of electric light and power, telephones, &c., in connection with large institutions. The salary offered is £150 per annum, plus War Bonus at Civil Service rates (at the present time £183 9s. 2d. per annum).
Candidates must not be less than 25 nor more than 35 years of age.
Application forms can be obtained from the undersigned on and after Monday, 6th December, 1920, and must be returned, accompanied by copies of testimonials, not later than Ten a.m. Friday, 17th December, 1920.
Envelopes to be endorsed "Application for Draughtsman." Requests for forms made by post must be accompanied by stamped addressed envelopes.
By Order, DUNCOMBE MANN, Clerk to the Board.
Office of the Board, Embankment, E.C. 4. L 85

THE MUNICIPALITY OF SINGAPORE. STRAITS SETTLEMENTS.

TWO ROAD SUPERINTENDENTS.

The Municipal Commissioners of Singapore require

Two Superintendents of Roads, age 28-35, preferably unmarried, on a three years' agreement. Applicants should have worked as masons, paviors, quarrymen, or in a similar trade. They must be accustomed to the control of labour, with experience as Roads Foremen or Assistant Roads Foremen upon the construction of granite macadam roads, including water-bound and tarred macadam and asphaltic mixtures, together with the waterproof coating of macadamised roads. Salary 5,400 dollars per annum. As the value of the dollar is fixed at 2s. 4d., the pay of the appointment will be equal to £630 per annum. A free passage will be provided, with half pay during the voyage out. The selected Candidate must pass a Medical Examination.
Applications, marked on cover "Road Superintendent," stating whether married or single, age, place of birth, and giving details of training and experience, referring to the above requirements in detail, with dates, accompanied by copies (only) of testimonials, and also personal references, must be lodged with Messrs. C. C. LINDSAY & PEIRCE, MM.Inst.C.E., 180, Hope Street, Glasgow, Agents to the Commissioners, not later than Tuesday, 14th December, 1920. L 3

Wanted, First-class Shop SUPERINTENDENT for small Works, used to handling both skilled and unskilled labour in the manufacture of small electrically operated tools; a man with first-class experience in repetition production and working to very fine limits. State age, experience and salary required.—Address, L 16, Offices of ENGINEERING.

Required, First Assistant to Engine Shop Manager with full knowledge of the latest shop practice relative to construction and erection of all types including the largest of Marine reciprocating engines, turbines and oil engines. State full particulars as to age, salary and experience.—Address, L 50, Offices of ENGINEERING.

Works Manager.—First-class man of proved organising and executive ability REQUIRED, for up-to-date Works, producing machine-cut gearing and engineering work in connection with large power transmission. Pay roll of 1,000. To a really live man with the necessary capabilities, a liberal salary will be paid, and the position will be an improving one. Only energetic men who have successfully filled similar position need apply. Application in confidence, stating age, and fullest particulars of experience and capabilities, with salary required, to DAVID BROWN & SONS (Hudd.), LTD., Park Gear Works, Lockwood, Huddersfield. L 5

Scientific Assistant in a Government Research Laboratory WANTED immediately. Experience in Engineering Research or in developing inventions commercially, skill and ingenuity of high order and academic distinction all desirable. Salary according to qualifications. —Replies to BOX 585, c/o C. MITCHELL & Co., Ltd., 1, Snow Hill, Holborn Viaduct, E.C. 1. L 88

Wanted, Works Chemist to take charge of Cement Works Laboratory. Good Organiser, state qualifications and salary.—Address, L 69, Offices of ENGINEERING.

Assistant Buyer.—Thorough knowledge purchase of Engineering and Building Materials. Salary £5 to £6.—Application, stating experience, to UNITED GLASS BOTTLE MNFRS., Ltd., Anchor & Hope Lane, Charlton. L 63

Estimator Wanted at Once for Engineer's London office. Structural and mechanical work. First rate men only need apply.—Address, L 46, Offices of ENGINEERING.

Lady Clerk (16 to 18) Re- QUIRED at end of year in Marine Consulting Engineer's Office, London (City). Must be willing to learn general office routine, including drawing and calculations. Fair typist and Shorthand. State qualifications and salary expected.—Address, L 84, Offices of ENGINEERING.

Pupil Required by Consulting Engineer, Westminster. Varied work, civil and mechanical. Small premium.—BOX 4306, c/o BROWN'S, 39, Tothill Street, Westminster. L 138

Required for a Government Establishment near London. TEMPORARY ASSISTANT, with good knowledge of physics; should have a University training and fair knowledge of French and German, especially with regard to technical terms. Commencing salary £496 per annum (inclusive of bonus).
Also TEMPORARY ASSISTANT with fair knowledge of Wireless Telegraphy and of Patent Law, good experience in extracting and recording scientific abstracts and with some experience of technical journalism and editing. University training necessary. Commencing salary £649 per annum (inclusive of bonus). Preference will be given in each case to ex-service men.
Apply BOX No. 1145, S. H. BENSON LTD., Kingsway Hall, London, W.C. 2. L 121

OUSE DRAINAGE BOARD.

ENGINEER.

Applications are Invited for the POSITION of ENGINEER to the Ouse Drainage Board. The Salary offered is £300 per annum together with an allowance of £200 per annum for travelling expenses. Office accommodation and staff will be found by the Board or an allowance made in lieu thereof.
Canvassing will be a disqualification.
Particulars of the duties and forms of application will be sent by me on receipt of a stamped addressed foolscap envelope.
Applications accompanied by three recent testimonials must be received by me not later than 15th December, 1920.
ASHLEY TABRUM, Acting Clerk.
County Hall, Cambridge. 30th November, 1920. L 51

Civil Engineer Required for the WAY & WORKS DEPARTMENT of the JAMAICA GOVERNMENT RAILWAY as Construction Engineer for two years' service—possibly a little longer. Salary £840 per annum rising by an increment of £50 to £900 per annum. Free first-class passages. Candidates, age 25–45, single, must be capable of preparing plans and specifications, laying out and supervising erection of station yards, locomotive running sheds, carriage and wagon depot, repair sheds, passenger station and general offices, and should be conversant with the erection of signals and interlocking.—Apply at once, in writing, stating age and brief details of experience, to THE CROWN AGENTS FOR THE COLONIES, 4, Millbank, London, S.W. 1, quoting M/10535. Applicants must have served in some branch of H.M. Forces during the late War unless satisfactory reasons for not having done so can be furnished. L 89

LITERATURE.

Space, Time, and Gravitation: an Outline of the General Relativity Theory. By A. S. EDDINGTON, M.A., M.Sc., F.R.S., Plumian Professor of Astronomy and Experimental Philosophy, Cambridge. Cambridge: University Press, 1920. [Price 15s.]

MEN'S minds have been exercised and agitated for some time past by the controversy that has arisen round the theories deduced from the general problem of relativity, culminating in the proposition that Einstein has enunciated to explain the phenomena of gravitational force. These theories have generally been accepted by those who are fitted by training to criticise and discuss the evidence on which the theory rests. The effort that many make to grasp the argument is truly pathetic, and it behoves those who are responsible for the disturbance of thought to give assistance to their less favoured brethren and to help them to a clearer vision. Professor Eddington in this work makes an earnest effort to supply this assistance, and explains as lucidly as the subject permits the revolution of thought in physical science, provoked by following the principles of relativity to their logical conclusions. In undertaking this task, he practically denies himself the use of mathematical language and symbols, but no one must expect from this exclusion that the work is easy reading. Will the average man accustomed to weigh evidence and to order his life by acquired experience and knowledge, but who has not lived in an atmosphere of mathematical symbols and has not appreciated the aims of modern mathematicians, grasp the argument in its integrity and be able to draw his own conclusions with certainty and conviction? That is the question that ought to be answered here and now, and regretfully, we think the answer must be in the negative. Those who want to get a clear insight into a difficult problem, those who have felt the insufficiency or the ambiguity of the Newtonian law of gravitation, and demand something more satisfying, that will accommodate itself to the new facts or explain what is obscure, will hail the book with delight, but we imagine that these form only a small portion of the public that Professor Eddington is addressing. His object, as we understand it, is to ask for the applause of the world for Einstein's conception, his reward would be found in the homage that men would pay to the new idol, not blindly as a concession to authoritative teaching, but with a willing assent founded upon firm conviction and logical demonstration. We think he will be disappointed. Those who have learnt that mass depends upon velocity, and have felt the necessity of amending, or defining the meaning of the product of the masses of the two bodies that occur in the Newtonian law, or have been uneasy for a want of exact definition of distance in the inverse law, or have been conscious of the difficulties attending the conception of inertia, will be glad to see their doubts handled with the confidence of knowledge and the ease of a master, but the attitude of the man of no specialised reading will be one of indifference or possibly hostility. The careless Gallio does not concern us, he is excluded because the argument, lightened as it is by illustration and instructive analogies, requires for its comprehension an amount of mental exertion that such an one is not prepared to give.

The educated man finding pleasure in exerting his faculties to the utmost will repeat, to some extent, the experience of a sixteenth century Cardinal, who made acquaintance with the teaching of Copernicus or Galileo and found his cherished, beliefs failing him. Each is required to overthrow or to modify, his previously accepted beliefs, and this necessity is forced on him by external circumstances. He has taken no part in the revolution in which he is engulphed, he may not admit its necessity nor perceive its importance but he has to answer the question, Is it true? He may be conscious of the soundness of the argument and charmed with the logical sequence of statement but nevertheless he has to suffer the annoyance of rearranging his principles and of facing new problems against which his conservatism revolts and urges him to find grounds for rejecting new creeds. Old prejudices block the way and experience counsels caution. The Newtonian theory which has successfully withstood many attacks, is not to be surrendered on light grounds. Evidence is needed as well as reasoning, and what is the value of the evidence on which he is bidden to build was the question of the sixteenth century as it is now. An experiment made by two physicists with the view of determining whether the ether, in and near the earth, was carried along by the earth in its motion or whether it slipped through the interstices between the atoms led to a result inconsistent with previous suppositions and hypotheses. To reconcile the apparent contradiction, an ingenious Irishman suggested a method that succeeded in captivating the world of science, which has since rioted in a new geometry, for which hitherto no use had been discovered. But even if an explanation, the outcome, not of external observation but of the nature of a happy conjecture, fascinated and satisfied the rising intellects, can it be supposed that the solution is unique. "If I surrender my judgment to this demand shall I not be required to subscribe to some new doctrine," is the cry of the man who would escape trouble. The history of the ether itself suggests caution. Created to explain certain phenomena, hailed with enthusiasm and regarded as a marvellous work of the scientific imagination, this vehicle of transmission has fallen into discredit, with none to do it reverence. Long ago we were told that the only function of the word was to furnish a nominative case to the verb "to undulate," and now the author with more sincerity and greater knowledge, gravely tells us that the ether "has ceased to take any very active part in physical theory and has, as it were, gone into reserve." If a modern writer on electromagnetic theory postulates an all-pervading ether, it merely serves as a background for an electromagnetic vector and the ether is thenceforward banished from the enquiry. If the votaries of science dismiss one of their cherished fictions thus summarily in order to sport in fourth dimensional space, or it may be in space of n dimensions, what hope of permanency of exact and lasting knowledge among those fleeting fancies which pose for a while as scientific fashion dictates, and then depart to make room for something more extravagant, more chimerical.

Practically the same question that the Roman hierarchy set to themsleves concerning Galileo recurs again. Is it desirable to disturb preconceived notions that have served the purpose of life so well? Fitzgerald's measure may assume weird shapes and vary in length as it points in various directions in space, but weights and measures are unaltered by a more exact attempt to define gravity, the division of time is satisfactory and precise enough to regulate the necessities of life, the rules of navigation are stereotyped, and when astronomers next collect to determine the position of the stars round an eclipsed sun, they will rely on the places of the sun and moon, computed from the tables of Newcomb and of Brown, constructed on the effete method of Newtonian dynamics. The innovator and the iconoclast cannot expect an easy time, as Galileo found, and occasionally a sense of depression seems to affect the author. "However successful the theory of a four dimensional world may be, it is difficult to ignore a voice inside us which whispers 'at the back of your mind, you know that a fourth dimension is all nonsense.'" Just as Galileo must have heard the idea of a rotating world ridiculed and derided. Professor Eddington, knowing that the marvels of one age become the commonplaces of a later, entertains little doubt of the ultimate triumphs of the fourth dimension. And he is very patient with the infirmities of those who have not the necessary scientific imagination, for he knows, too, that it is very difficult to imagine conditions that are outside our experience, and a fourth dimension is certainly difficult to conceive or to picture. The mathematician has not the same difficulty, he merely increases the number of his equations and modifies his notation, and only realises the embarrassment when he has to interpret these equations for an enquiring, but not mathematical, mind. Very few can attach any definite idea to what is meant by time being a fourth dimension, and we doubt if the bewildered neophyte will get any great assistance from the author's attempt at precise definition. "It is in the external world," he says, "that the four dimensions are united—not in the relations of the external world to the individual which constitute his direct acquaintance with space and time. Just in that process of relation to an individual, the order falls apart into the distinct manifestations of space and time."

A point of real importance in this book is the uncompromising attitude it takes up with regard to the four dimensional world, and the confidence with which a great number of remarkable phenomena are deduced from the principles of relativity and equivalence. However impossible to visualize, the four dimensional world is not a fiction, spider wove from the analyst's own brain, nor a contrivance introduced to illuminate the obscure. The three dimensional world, as unsophisticated people imagined it, is obsolete and must be replaced by four dimensional space time with non-Euclidean properties. "The four dimensional world is no mere illustration, it is a real world of physics arrived at in the recognised way by which physics has always sought for reality." This point is only the beginning of the enquiry, which carries wide consequences, but it is necessary to emphasize it, because a more or less vague notion prevails that no real importance can attach to such conception, but it is as real to the physicist of to-day as was the idea of a rotating earth to Galileo. Doubtless the phenomena of day and night could be equally well explained by the daily revolution of the sun about the earth, but no one doubts now that such a view is untenable. Similarly, the law of gravitation as presented by Newton explains many observed facts, and it is only in most exceptional cases that the difference between the effect of the two laws is appreciable. The explanation afforded by the view of Einstein of the discordance between the observed and computed motion of the perihelion of Mercury, and of the displacement of star images in the neighbourhood of the sun's disc, though forming a powerful appeal to public support is of quite secondary importance. If the theory could not have been submitted to the touchstone of experiment, the analyst would have been equally certain of the accuracy of his deductions, and would have regarded its conception and development as one of the great triumphs of human thought. The theory has predicted a result, subsequently verified by experience, and without this aid it might have shared the same fate that has overtaken the many others that have enjoyed a moment's publicity. The philosophical physicist aims at a higher goal than the reconciliation of discrepancies between observation and theory, his field of exploration is the whole world of perception, on which depends the laws of mechanics, including gravitation and the true conception of the ordinary space and time of experience.

The Newtonian law of gravitation can be defined in a few terse expressions, which are generally known, but it is not possible to define Einstein's theory in the same simple way, and it would be unwise to attempt a summary of this theory in a few sentences. Doubtless it would be found on strict analysis that not only has Professor Eddington been misrepresented, but that approval had been given to a vast number of heresies. To remain on safe ground it may be said that space around matter is distorted, or curved, but "no higher than the first degree," by an amount which decreases as distance from the matter increases. On this ground the phenomenon of gravitation is due to a particle trying to find the easiest path through this distorted space. The path through the curved space or hummock, the geodesic, will not coincide with that which would be pursued in Euclidean space, and the difference between such a path and that actually travelled, is precisely that which would be produced, if space were regarded as Euclidean and the particle been acted upon by that force, which has hitherto been called gravitational attraction. It is evident that the paths, the tracks of the geodesics on the hummock, must agree very closely with the results deduced from the law of gravitation, and indeed for a particle having small velocity the acceleration towards the sun is very approximately m/r^2, as shown in the Principia. On this view, the relation between Einstein and Newton resembles that between Newton and Kepler. The latter determined empirically certain

laws which accurately represented the observations that could be made in that day. Newton showed that these laws could be established as the necessary consequences of a more general law. Einstein, by utilising a fourth dimension, shows that gravity and inertia, the conservation of mass, of energy, and of momentum, are all consequences of a more general principle. Perhaps the next step will be to show why the world is four dimensional, for the work of the metaphysician is only beginning.

Manufacture and Uses of Alloy Steels. By Henry D. Hibbard. New York: J. Wiley and Sons; London: Chapman and Hall, Ltd. [Price 7*s.* 6*d.* net.]

The contents of this book were originally published by the American Bureau of Mines as one of their official monographs, and it has been included by the present publishers in a new series of engineering text books which they propose shall deal more with the practical aspects of their subjects than with the theoretical questions which their consideration involves. The idea is of course good, but in this instance the book is more a compilation of information already published than a treatise on the manufacture of alloy steels, and it deals only in a very sketchy and incomplete way with the processes which have been developed to manufacture alloy steels commercially, and makes no mention at any time of the difficulties which have to be overcome in order to produce a satisfactory product. It is, in other words, a book for the user and engineer rather than for the manufacturer, and from this point of view it forms a convenient hand-book of the compositions and types of special steels which have been found of commercial use, together with some of their physical properties.

One interesting feature of the book is an estimate of the production of special steels in America during 1913, and this indicates the extent of the industry, largely of course developed for motor-car purposes.

	Tons.
Tungsten steels	(approx.) 5,500
Chromium steels	6,000
Manganese steels	36,000
Nickel steels	50,000
Ni-Chrome steels	100,000
Silicon steels	25,000
Cr-Vanadium steels	75,000
High-speed steels	7,000
	304,500

Chapter II deals with plain tungsten steels in a very brief manner and makes no mention of the results of Swinden, Bohler, or the methods of annealing such steels which are of the utmost importance. Chapter III on chromium steels is also scrappy and does not go beyond a brief mention of some of the uses for which chromium steels have been adopted. Chapter IV, on manganese steel is better, and might well have been made the model for the other chapters, while the account in the next chapter on the plain nickel steels is also clear and succinct. These are, of course, the commonest of special steels and information concerning their manufacture and properties is already widely diffused.

The remainder of the book deals with chrome nickel, silicon, chrome-vanadium and high-speed steels, but only the briefest outline is given of their properties and uses, and we greatly doubt whether anyone wanting information on the question of alloy steels would find what he is seeking in this book if he has not found it elsewhere.

The appearance and printing of the book are excellent, and as an elementary text-book on the subject it should be of use to many engineers who want some acquaintance with the properties of alloy steels and do not necessarily require the details which the metallurgist would expect.

Bridge and Structural Engineers' Handbook. By Adam Hunter, M.Inst.C.E. London: E. and F. N. Spon, Ltd., 57, Haymarket. [Price 21*s.* net.]

Although published primarily to standardise the practice of Sir William Arrol and Co., Limited, in the design of cranes, road, and railway bridges, foundations and workshop buildings this work should prove of inestimable value to engineers engaged in the design and construction of such works. The data and general specifications are in accordance with British practice for first-class structures, and contain the standardised practice of eminent British, American, and Continental engineers.

The formulae and data are given in a compact form for easy reference and use in the office. No mathematical proofs are given, but references are given where fuller information can be obtained. A very complete collection of mathematical formulae and graphical diagrams for the calculations of bending moments, shearing forces and deflections of horizontal and inclined beams, columns axially and eccentrically loaded, framed girders and portal bracings are given. These formulae have been extended beyond those usually given in textbooks to meet conditions which have arisen in the actual design of structures. Practically all cases of concentrated and uniformly distributed moving loads on beams are given by analytical and graphical methods of calculation as well as the method of influence lines. Practical applications of obtaining the deflections of framed structures are given when the elastic deformation of each member from the stress upon it is known. A series of recent tests by the American Society of Civil Engineers on steel columns having a slenderness ratio of from 50 to 155 $\frac{l}{r}$ are tabulated, and it is interesting to note that these tests have indicated that no column has a greater ultimate strength than about the elastic limit of the material. Considerable information is supplied on the permissible and actual loads on existing foundations together with the ascertained skin frictions of bridge pier foundations. The results of actual tests on the ultimate compressive strength of timbers of large scantlings are specially valuable as the strengths usually quoted are from the tests of small specimens, specially selected and free from the knots, shakes, and other inherent defects usually present in timber of large scantlings. The scantlings of roof trusses, and the leading dimensions and weights of overhead electric cranes should prove useful to those engaged in the design of workshop buildings and gantries. A considerable amount of information on wind pressure is supplied, and we have here a valuable collection of experimental data on the effects of wind pressure on buildings and bridges, on the sheltering effects of girders and other surfaces, and the influences of surrounding objects on the resulting pressures. The importance of the suction or negative pressures of the wind is emphasised by these experiments. It is to be regretted that the author has not shown the experimental results of the wind pressure tests on the airship shed graphically on the diagrams as a better conception of the negative pressures and the effects of the wind screens would thereby be given. The general specifications for the calculation and design of overhead travelling cranes, giant cantilever cranes, superstructures of road and railway bridges, steel trestles for bridge piers, swing bridges and workshop buildings are a valuable contribution to engineering literature on these subjects and should help to standardise general practice in their design. An excellent index is provided for this book which contains much more information than is indicated by its title.

BOOKS RECEIVED.

A Course of Modern Analysis; An introduction to the General Theory of Infinite Processes and of Analytic Functions; with an Account of the Principal Transcendental Functions. By E. T. Whittaker, Sc.D. F.R.S., and G. N. Watson, Sc.D., F.R.S. Third, edition. Cambridge: University Press. [Price 40*s.* net.]

The A.B.C. of Storage Battery Management. By Ernest C. McKinnon, A.M.I.E.E. London: Electrical Press, Limited. [Price 3*s.* 6*d.* net.]

General Design of Warships. By William Hovgaard, M.Inst.N.A. London: E. and F. N. Spon, Limited. New York: Spon and Chamberlain. [Price 32*s.* net.]

Cardiff, 1919. An Illustrated Handbook. Issued under the auspices of City Council (Development Committee), Cardiff. Edited by D. Willson Lloyd, B.A., F.S.S. Cardiff: The Business Statistics Company, Limited. [Price 5*s.* net.]

Pure Mathematics for Engineers. Parts I and II. By S. B. Gates. B.A. London: Hodder and Stoughton, Limited. [Price 4*s.* 6*d.* net each.]

Dredging Engineering. By F. Lester Simon, B.S. in C.E. Assoc.M.Am.Soc.C.E. New York and London: McGraw-Hill Book Company, Inc. [Price 15*s.* net.]

The Marine Engineer's Handbook. Frank Ward Sterling, Editor-in-Chief. New York and London: McGraw-Hill Book Company, Inc. [Price 45*s.* net.]

United States Geological Survey. Water Supply Papers. No. 380. *The Navajo Country. A Geographic and Hydrographic Reconnaissance of Parts of Arizona, New Mexico and Utah.* By Herbert S. Gregory. [Price 80 cents.] No. 389. *Surface Water Supply of the United States,* 1914. Part IX. *Colorado River Basin.* No. 390. Part X. *The Great Basin.* [Price 20 cents.] No. 402. 1915. Part II. *South Atlantic and Eastern Gulf of Mexico Basins.* [Price 15 cents.] No. 403. 1915. Part III. *Ohio River Basin.* No. 404. 1915. Part IV. *St. Lawrence River Basin.* [Price 10 cents.] No. 406. Part VI. *Missouri River Basin.* [Price 20 cents.] No. 407. Part VII. *Lower Mississippi River Basin.* [Price 10 cents.] No. 408. Part VIII. *Western Gulf of Mexico Basins.* [Price 10 cents.] No. 409. Part IX. *Colorado River Basin.* [Price 20 cents.] No. 410. Part X. *The Great Basin.* [Price 20 cents.] No. 412, Part XII A. *Pacific Slope Basins in Washington and Upper Columbia River Basin.* [Price 35 cents.] No. 413. Part XII. *North Pacific Drainage Basins, Snake River Basin.* [Price 15 cents.] No. 414. Part XII. *Lower Columbia River and Pacific Drainage Basins in Oregon.* [Price 20 cents.] No. 415. *Surface Waters of Massachusetts.* By C. H. Pierce and H. J. Dean. [Price 45 cents.] No. 417. *Profile Surveys of Rivers in Wisconsin.* [Price 45 cents.] No. 418. *Mineral Springs of Alaska.* By Gerald A. Waring. *With a Chapter on the Chemical Character of Some Surface Waters of Alaska.* By R. B. Dole and A. A. Chambers. [Price 25 cents.] No. 419. *Profile Surveys in* 1915 *in Skagit River Basin,* Washington. [Price 15 cents.] No. 420. *Profile Surveys along Henry's Fork, Idaho, and Logan River and Blacksmith Fork, Utah.* [Price 10 cents.] No. 421. *Profile Surveys in* 1915 *along the Rio Grande, Pecos River, and Mora River, New Mexico.* [Price 15 cents.] No. 423. *Geology and Water Resources of Big Smoky, Clayton, and Alkali Spring Valleys, Nevada.* By Oscar E. Meinzer. No. 424. *Surface Waters of Vermont.* By C. H. Pierce. [Price 25 cents.] No. 425–B. *Ground Water for Irrigation in Lodgepole Valley, Wyoming and Nebraska.* By Oscar E. Meinzer. No. 425–C. *Hydraulic Conversion Tables and Convenient Equivalents.* No. 425–D. *Ground Water in Reese River Basin and Adjacent Parts o, Humboldt River Basin, Nevada.* By Gerald A. Waring. No. 425–E. *Ground Water in Quincy Valley, Washington.* By A. T. Schwennesen and O. E. Meinzer. No. 426. *Southern California Floods of January,* 1916. By H. D. McGlashan and F. C. Ebert. [Price 15 cents.] No. 428. *Artesian Waters in the Vicinity of the Black Hills, South Dakota.* By N. H. Darton. [Price 15 cents.] No. 430. *Surface Water Supply of Hawaii, July* 1, 1913, *to June* 30, 1915. [Price 20 cents.] No. 431. *Surface Water Supply of the United States,* 1916. Part I. *North Atlantic Slope Drainage Basins.* [Price 15 cents.] No. 432. Part II. *South Atlantic and Eastern Gulf of Mexico Basins.* [Price 10 cents.] No. 433. Part III. *Ohio River Basin.* [Price 20 cents.] No. 434. Part IV. *St. Lawrence River Basin.* [Price 10 cents.] No. 438. Part VIII. *Western Gulf of Mexico Basins.* [Price 10 cents.] No. 441. Part XI. *Pacific Slope Basins in California.* [Price 25 cents.] Washington: Government Printing Office.

United States Geological Survey. Professional Papers. No. 101. *Geology and Paleontology of the Ratou Mesa and other Regions in Colorado and New Mexico.* By Willis T. Lee and F. H. Knowlton. No. 108–A. *Baked Shale and Slag formed by the Burning of Coal Beds.* By G. Sherburne Rogers. No. 108–B. *The Newington Moraine, Maine, New Hampshire, and Massachusetts.* By Frank J. Katz and Arthur Keith. No. 108–E. *Geologic History Indicated by the Fossiliferous Deposits of the Wilcox Group (Eocene) at Meridian, Mississippi.* By Edward W. Berry No. 108–K. *The Halderberg Limestone of Central Pennsylvania.* By John B. Reeside, Junior. No. 120–G. *New Graphic Method for Determining the Depth and Thickness of Strata and the Projection of Dip.* By Harold S. Palmer. Washington: Government Printing Office.

Repairing of Locomotives. Section I. *Examinations, Stripping, Boiler Defects.* By E. L. Ahrons, M.I.Mech.E., M.I.Loco.E. London: Locomotive Publishing Company, Limited. [Price 3*s.* 6*d.* net.]

Guild Socialism Re-stated. By G. D. L. Cole. London: Leonard Parsons, Limited, 19, Portugal-street, W.C. 2. [Price 6*s.* net.]

Republica Argentina, Obras Sanitarias de la Nacion, Sancamiento del Territorio de la Capital Federal Projecto de Desagües de Aguas Pluviales. Vol. I. *Texto.* Vol. II. *Planos.* Buenos Aires: Talleres Gráficos del Ministerio de Obras Públicas.

University of London, University College, Calendar Session 1920–21. London: Taylor and Francis.

The Motor, Marine and Aircraft Red Book, 1920. Compiled by W. C. Bersey and A. Dorey. London: Technical Publishing Company, Limited. [Price 21*s.* net.]

Plantation Rubber and the Testing of Rubber. By G. Stafford Whitby, Ph.D., M.Sc., A.R.C.Sc. London: Longmans, Green and Co. [Price 28*s.* net.]

Finsbury Technical College Defence Committee.—A meeting of past and present students and others interested in the college has formed a Defence Committee to consider the possibility of helping in any way the carrying on the work of the college, and thus obviate its closing, as announced by the City and Guilds, in July, 1921. Applications, with entrance fee 2*s.* 6*d.*, should be sent to Dr. Atkinson, Finsbury Technical College, Leonard-street, E.C. 2.

EXACT DATA ON THE PERFORMANCE OF STEAM BOILER PLANTS.

No. IV.—*Average Figures for the Performance of Some Different Types of Steam Boilers.*

By DAVID BROWNLIE, B.Sc., Hons. (Lond.), F.C.S., A.I.Mech.E.

IN this article I propose to deal with the question of the average figures being obtained under ordinary working conditions with different types of stationary land steam boilers. Figures of this description are of practical interest because, as already shown in previous articles, probably over 95 per cent. of the boiler plants of Great Britain are run almost entirely in the dark as to their performance.

Consequently, "rule-of-thumb" figures have to be used instead of exact figures. Thus, for example, if a firm desire to instal additional engine power, then to calculate the corresponding increased steam demand they obtain from the engine makers a more or less general statement as to the amount of steam required per indicated horse-power.

They then calculate by "rule-of-thumb" figures the amount of coal equivalent to the steam required, and in some such way they arrive at the number of extra boilers necessary, having also obtained similar rough and ready figures from boiler makers, economiser makers, and so on. In this free and easy manner the great majority of boiler and power plants are being erected or enlarged in Great Britain to-day. In a somewhat similar way, in general, the electrical engineer, the architect and quantity surveyor, and, in fact, everyone connected with industry, arrive at their calculations for the performance of steam boiler plants.

The whole principle is, of course, thoroughly wrong and unscientific, and is rendered still further so by the fact that much of this "rule-of-thumb" data is hopelessly inaccurate. Since it is tolerably certain that such methods will generally continue to be used for many years, at any rate the least that can be done is to employ data which are reasonably accurate, and the object of this paper is to give such data, while recognising at the same time that even with fairly accurate data the whole system is not in accordance with modern methods of economical steam generation.

The data given in this paper are based on about twelve years' continuous experience of testing and re-organising existing steam boiler and power plants, and in designing new plants, and include the complete scientific investigation of nearly 500 steam boiler plants in about 50 different industries, with a total coal bill of nearly 5,000,000 tons per annum, together with the inspection of about 2,000 plants.

The information at present available contains the most extraordinary differences of opinion. Thus, according to Kempe ("Engineer's Year Book," 1920.):—

Description of Boiler.	Efficiency.
	per cent.
Small cylindrical boiler. (No economisers) ..	45–55
Large cylindrical boiler with economiser	60–70
Small water-tube boiler with economiser	50–60
Large water-tube boiler with economiser	70
In very good condition	70–75
Locomotive boiler, moderately fired	65–70
Marine boiler, well fired	60–70

W. S. Hutton ("Steam Boiler Construction," latest edition, 1916) gives a number of figures for the performance of various types of boilers: "which may generally be obtained in practice with boilers having tolerably clean heating surfaces when fired with good coal," as follows:—

Type of Boiler.	No. of Tests Given.	Evaporation. Pounds Water from and at 212 Deg. F.
"Lancashire"	22	8·25–12·02
"Cornish"	7	7·75–11·56
"Egg-ended"	6	6·52– 8·56
"Vertical"	15	5·57–10.21
"Water-tube"	73	7·02–13·40

Again, some data supplied by Molesworth are:—

Description of Boiler.	Pounds Water from and at 212 Deg. F., Evaporated per Pound of Average Coal.
"Egg-ended"	8·0
"Cornish"	8·0
"Lancashire"	9·0
"Water-tube"	8·0
Ordinary "Marine"	9·5
"Tubular"	9·5
"Locomotive"	10·5
"Torpedo boat"	13·0

Donkin, in his book on "Heat Efficiency of Steam Boilers," gives 50 tables containing the results of 425 experiments on different boilers. The results as given in this book are summarised as follows (being for the boilers only without economisers):—

Type of Boiler.	No. of Experiments.	Average Efficiency.	Average of Two Best Results.	Worst Result.
		per cent.	per cent.	per cent.
Water-tube, 1¼-in. tube..	6	77·4	84·1	66·6
Locomotive	37	72·5	83·3	53·7
Lancashire	10	72·0	74·4	65·6
Two-storey	9	70·3	76·1	57·6
Two-storey	20	69·2	79·8	55·9
Dry back	24	69·2	75·7	64·7
Return tube	11	68·7	81·2	56·6
Cornish	25	68·0	81·7	53·0
Cornish	9	67·0	81·0	55·0
Wet back	6	66·0	69·6	62·0
Elephant	7	65·3	70·8	58·9
Water-tube, 4-in. tubes..	40	64·9	77·5	50·0
Lancashire	40	64·2	73·0	51·9
Cornish	3	62·7	65·9	60 0
Lancashire	107	62·4	79·5	42·1
Dry back	6	61·0	72·4	54·8
Lancashire, 3-flue ..	6	59·4	68·7	52·0
Elephant	8	58·5	65·5	54·9
Lancashire	8	57·3	74·3	45·9
Vertical	5	56·2	76·5	44·2

Very great variations were met with, and for example, as seen in the 107 tests on "Lancashire" boilers, the efficiency varied from 79·5 per cent. down to 42·1 per cent.

Many boiler tests have been carried out by Barrus in America, and the results of over 300 tests are given by him as follows:—

Water Evaporated from and at 212 Deg. per Pound of Combustible.	No. of Tests with Anthracite.	No. of Tests with Anthracite and Soft Coal.	No. of Tests with Semi-bituminous Coal.	No. of Tests with Bituminous Coal.
Over 12·0 ..	2	2	45	3
11·5 to 12·0 ..	2	—	37	2
11·0 to 11·5 ..	7	7	45	7
10·5 to 11·0 ..	17	7	44	7
10·0 to 10·5 ..	9	3	24	3
9·0 to 10·0 ..	6	3	7	17
8·0 to 9·0 ..	2	2	2	5
7·0 to 8·0 ..	—	1	—	3
Total ..	45	25	204	47

Andre states that 1 lb. of the following coals will evaporate, under ordinary practical conditions, the following amount of water from and at 212 deg. F.:—

	Lb.
Gaseous coals	6·25
Bituminous-fuliginous	8·00
Flaming..	8·75
Clear-burning	9·25
Semi-bituminous	9·10
Anthracite	9·20

Again, it is often generally assumed by engineers that average quality coal will evaporate 7 lb. to 8 lb. of water from and at 212 deg. F., per pound of coal, and engine builders to-day in their specifications for large factory engines giving the steam consumption, say 12 lb. steam per indicated horse-power, usually calculate this also in terms of coal, stating that on the average 8 lb. of water are evaporated per pound of coal.

In stating the results in this paper, I have given the figures for (1) "Lancashire" boiler plants; (2) "Water-tube" boiler plants; (3) Small installations of "Lancashire" or "Cornish" boilers; (4) Small vertical boiler plants; and (5) "Egg-ended" boiler plants. In each case the figures are calculated from a standard trial of 12 hours, together with a check test of one complete week (168 hours).

It is no use attaching much importance from a practical point of view to abnormal test figures obtained under ideal conditions, such as contained in the catalogue of many firms supplying plant, machinery and appliances for steam raising.

As already pointed out in previous articles, the general methods of steam generation in vogue are out of date. If scientific methods of control were adopted, the efficiency of boiler plants generally would be considerably higher. Accordingly, in expressing the results, I have given first of all, as much the most important, the figures being obtained to-day under average conditions without any proper methods of control, this applying to at least 85 per cent. of the boiler plants of the country using these particular boilers. I have also given in the case of "Lancashire" and "Water-tube" boilers, corresponding figures for plants run on the most modern lines, which apply only to probably about 5 per cent. of boiler plants, and at the same time I have given figures for very bad plants, probably typical of about 10 per cent. of the plants of the country.

In order to afford comparative figures, the coal used throughout has all been calculated as 12,000 British thermal units per pound, and 10·5 per cent. ash, which represents roughly the average quality, or slightly above the average used throughout the country. The performance figures obtained on any boiler plant depend very largely on the quality of the coal used, and this point is not always realised by steam users. Thus, if a coal of 12,000 British thermal units deteriorates, say 10 per cent., to 10,800 British thermal units, the loss in efficiency in practice is much more than 10 per cent. The difficulties caused by the accumulation of ash, and the reduction of radiant heat causes a much greater drop in efficiency than that corresponding to the mere reduction in heating value, and the net reduction is, say, 15 per cent. to 17½ per cent. instead of 10 per cent.

In the same way, an increase in heating value of 10 per cent., say from 12,000 British thermal units to 13,200 British thermal units, gives more than the mere 10 per cent. increase in heating value, because of the greater freedom from ash and the increased radiant heat. These facts must, therefore, be borne in mind in considering the figures given on the different types of plants.

For example, Bryan Donkin and A. B. W. Kennedy published in 1897 ("Experiments on Steam Boilers," Offices of ENGINEERING) a series of experiments on the performance of a number of types of steam boilers comprising 21 separate determinations, including "Vertical," "Tubular," "Lancashire," "Locomotive," "Water-tube," "Cornish," "Cornish Multitubular" and "Elephant" boilers. These experiments, however, do not give us much data of practical value, because they were carried out under ideal conditions with coal of extraordinarily good quality, namely, the finest Welsh steam coal. Thus the heating value of the dried coal was no less than 15,560 British thermal units per pound, with only 3 per cent. ash, and the theoretical evaporation of 1 lb. of the dried coal from and at 212 deg. F. was given as 16·1 lb. of water. As typical of the figures obtained, a "Lancashire" boiler gave 70·4 per cent. efficiency without economisers, and 9·92 lb. of water evaporation per pound of coal. A "Cornish" boiler showed 78·3 per cent. efficiency with 11·4 lb. of water from and at 212 deg. F. per pound of coal, whilst a "water-tube" boiler showed 74·4 per cent. efficiency and 9·90 lb. of water per pound of coal.

These results, therefore, only apply to purely abnormal conditions, and are of little use in arriving at average figures for boiler plants as generally working in industry.

Also for the purpose of comparison, I have taken an average price of 40s. per ton, and calculated the day's test and the week's test in pence per 1,000 gallons, together with a coal bill for a standard evaporation of 20,000,000 gallons of water.

Further, in taking the temperature of the feed water (as going into the plant) an average figure of 110 deg. F. has been taken throughout, because this is about the average in general use, being the ordinary "hot well" temperature. In studying the figures, therefore, if the temperature of the inlet water of a particular plant is different, every 11 deg. F. can be taken as equivalent to 1 per cent. of the coal consumption, higher or lower. Thus

if the feed water be about, say, 99 deg. F., then the coal consumption figures will be increased about 1 per cent.

"Lancashire" Boiler Plants.

The annexed table gives the average figures for the performance of the "Lancashire" boiler and accessories, calculated in terms of standard boilers 30 ft. × 8 ft., with average grates 6 ft. × 3 ft. 2 in. A typical plant of four boilers is given, being about the average size, and for a different number of boilers the corresponding figures can easily be calculated.

As regards method of firing, hand and mechanically-fired plants are averaged together, as, in my opinion, there is little real difference in efficiency between hand and mechanically-fired "Lancashire" boiler plants with the present general methods of working. (See paper read March 20, 1920, before the Institution of Mechanical Engineers, "Exact Data on the Performance of Mechanical Stokers as Applied to 'Lancashire' or other narrow-flued Boilers.")

There is no doubt, in spite of the absence of a proper engineering census of the country, that the "Lancashire" boiler is the typical boiler in Great Britain, and there are very many more boilers of this type working than any other.

With regard to the following points:—

1. *Coal Burnt per Boiler per Hour.*—Calculated as 12,000 British thermal units coal the average figures can be taken as about 865 lb. per 30 ft. × 8 ft. boiler per hour, corresponding to about 22¾ lb. per square foot grate area per hour. A very bad plant will, as seen, burn less than this, whereas a plant on modern lines would give about 20 per cent. more duty in this respect.

2. *Water Evaporated per Boiler per Hour.*—Calculated at 110 deg. F. inlet temperature, the average is just below 6,000 lb. per 30 ft. × 8 ft. boiler. This is considerably less than is generally supposed, and most steam users imagine that something like 8,500 lb. is the figure being obtained; this however, does not apply to more than about 5 per cent. of the plants of the country. In general, the boiler plants of Great Britain are working at nothing like their proper output, which is interesting in view of the fact that hundreds of works are at the same time in continual trouble due to shortage of steam. In the case of the average bad plant, working without economisers, as already stated, if economisers are installed every 11 deg. F. rise in the feed-water temperature can be regarded as 1 per cent. saving in the coal consumption.

3. *Water Evaporated per Pound of Coal.*—This, of course, depends on the heating value of the coal and the temperature of the feed water, but taking, as usual, the averages of 12,000 British thermal units and 110 deg. F., the figure is 6·65 lb., corresponding to 7·62 lb. from and at 212 deg. F. For all practicable purposes, the figure can be taken as 6½ lb., corresponding to 7½ lb. from and at 212 deg. F. For bad plants and especially those without economisers, the figures are, say, 5½ lb. and 6½ lb., respectively. The figures often given in general engineering literature such as 9 lb. of water from and at 212 deg. F. per pound of coal are as averages quite erroneous, and do not apply to 95 per cent. of the plants of the country.

4. *Draught.*—The draught of the average boiler plant is obtained by means of a chimney (natural draught) giving a draught in the base of about 0·75 in. suction water gauge, which with the average flues and economisers corresponds to about 0·35 in. water gauge in the side flues. The height of a chimney corresponding to these figures is, roughly, say 125 ft. to 150 ft. with average flues. In the case of a bad plant a short chimney, say, 90 ft. to 120 ft. and cramped and defective flues, the draught corresponds to only about 0·5 in. water gauge in the chimney base. Without economisers this is equal to, say, 0·4 in. in the side flues. If economisers are installed under such conditions, say, an average of 320 tubes for four boilers, there is a very serious reduction in the draught, and in the side flues the figure would then only be about 0·20 in. water gauge. On a good plant, using mechanical-induced draught, the figure averages about 2 in. water gauge in the fan inlet, and 0·65 in. water gauge in the side flues, much thicker fires being used.

TABLE I.—Lancashire Boiler Plant.

	Bad Plant Representing, say, 10 per Cent. of Boiler Plants at Work in Great Britain	Ordinary Average Plant as being Generally Worked To-day, Representing 85 per Cent. of Plants at Work in Great Britain.	Most Efficient Plant Working under Modern Scientific Supervision or under Test Conditions, Representing only about 5 per Cent. of Plants at Work in Great Britain.
A. Working-Day Test.			
1. Number of boilers working	4	4	4
2. Grate area (total)	151·96 sq. ft.	151·96 sq. ft.	151·96 sq. ft.
3. Duration of test	12 hours	12 hours	12 hours
4. Price of coal used (per ton delivered)	40s.	40s.	40s.
5. Amount of coal used	36,249 lb.	41,504 lb.	50,870 lb.
6. Analysis of coal—British thermal units	12,000	12,000	12,000
7. Analysis of coal—ash	10·5 per cent.	10·5 per cent.	10·5 per cent.
8. Coal burned per boiler per hour	755·2 lb.	864·7 lb.	1,059·8 lb.
9. Coal burned per square foot grate area per hour	19·8 lb.	22·7 lb.	27·9 lb.
10. Water evaporated, pounds	204,000 lb.	276,000 lb.	408,000 lb.
11. Water evaporated per boiler per hour	4,250 lb.	5,750 lb.	8,500 lb.
12. Water evaporated per square foot grate area hour	111·3 lb.	151·3 lb.	223·7 lb.
13. Water evaporated per pound of coal	5·62 lb.	6·65 lb.	8·02 lb.
14. Equivalent evaporation from and at 212 deg. per pound of coal	6·42 lb.	7·62 lb.	9·28 lb.
15. Equivalent evaporation from and at 212 deg. F. per 1,000,000 British thermal units	535·1 lb.	635·0 lb.	856·7 lb.
16. Temperature of feed-water before economisers	110 deg. F.	110 deg. F.	110 deg. F.
17. Temperature of feed-water after economisers	No economiser	230 deg. F.	335 deg. F.
18. Percentage of coal bill saved by economisers	Nil	11·0 per cent.	20·4 per cent.
19. Draught in back flues of boilers	0·40 in. W.G.	0·35 in. W.G.	0·65 in. W.B.
20. Draught in chimney base	0·50 in. W.G.	0·75 in. W.G.	2·00 in. W.G.
21. Temperature of flue gases before economiser	500 deg. F.	600 deg. F.	650 deg. F.
22. Number of economiser tubes	No economiser	About 320 tubes	About 500 tubes
23. Temperature of flue gases after economisers	500 deg. F.	450 deg. F.	310 deg. F.
24. Analysis of boiler feed water—			
Degrees permanent	12 deg.	9 deg.	5 deg.
Degrees temporary	5 deg.	2 deg.	0 deg.
25. Percentage CO_2 in flue gases (continuous record on combustion recorder)	5·0 per cent.	7·5 per cent.	12·0 per cent.
26. Steam pressure (average)—(*a*) Gauge	60 lb.	75 lb.	159 lb.
27. Steam pressure (average)—(*b*) Absolute	75 lb.	90 lb.	174 lb.
28. Temperature of saturation of steam	307·4 deg. F.	320·3 deg. F.	370·0 deg. F.
29. Temperature of superheated steam	None	None	540 deg. F.
30. Steam or power used as auxiliary to production of steam	5·0 per cent.	2·5 per cent.	2·5 per cent.
31. Thermal efficiency of plant—			
(*a*) Net working efficiency of plant complete	49·2 per cent.	60·0 per cent.	79·0 per cent.
32. (*b*) Boilers only	51·8 per cent.	54·7 per cent.	59·5 per cent.
33. (*c*) Economisers only	Nil	6·8 per cent.	15·3 per cent.
34. (*d*) Superheaters only	Nil	Nil	6·2 per cent.
35. Cost in coal to evaporate 1,000 gallons of water	380·8*d.*	332·6*d.*	266·9*d.*
B. Long Check Test (One Week). (Say Two Shifts per 24 Hours.)			
36. Duration	168·0 hours	168·0 hours	168·0 hours
37. Price of coal used (per ton delivered)	40s.	40s.	40s.
38. Amount of coal used	120 tons	140 tons	230 tons
39. Water evaporated	149,180 gallons	203,840 gallons	404,430 gallons
40. Water evaporated per pound of coal	5·55 lb.	6·50 lb.	7·85 lb.
41. Cost in coal to evaporate 1,000 gallons of water	386·1*d.*	329·6*d.*	273·0*d.*
42. Coal bill for 20,000,000 gallons evaporated per annum	32,166*l.*	27,472*l.*	22,748*l.*

It must not be imagined, however, that if mechanical draught is installed without proper scientific supervision good results will follow. The average mechanical-draught plant running in Great Britain to-day is probably giving worse results than the average natural-draught plant, because mechanical draught is more "sensitive," and requires, for this reason, more skilled attention. The point is, however, that in my opinion mechanical draught rightly worked is, in most cases, essential to the highest efficiency.

5. *Temperature of Flue Gases.*—The gases leaving the boilers average about 600 deg. F. with coal of 12,000 British thermal units. On a bad plant with a poor draught and leaky brickwork, the figure is only about 500 deg. F., chiefly because of cold air leakages. In a most efficient plant the figure goes up to, say, 650 deg. F., because of tight brickwork and good fires with a minimum of excess air. With too much draught or "short circuiting" of the gases in the boiler seatings, however, the temperature may go as high as 800 deg. F. leaving the boiler.

6. *Quality of Feed Water.*—The average figures for feed water are about 11 deg. total hardness, that is 11 grains per gallon, and this means a considerable deposit of scale with a corresponding loss in efficiency. It is difficult to express the advantage of softening the feed water in figures of annual saving in the coal bill, but a good plant should not have a hardness of over 5 deg. to 6 deg., and a softening plant is necessary in average cases to obtain such figures. A typical average bad plant has, say 17 grains per gallon, which, of course, means serious scale troubles.

7. *Percentage* CO_2.—The average plant is only giving, say, 7·5 per cent. CO_2 in the side flues because of medium firing and leaky brickwork, whilst a very efficient plant is about 12 per cent. It must be remembered, however, that high CO_2 does not mean efficiency unless, at the same time there is no CO (carbon monoxide) present, and the figure for CO_2 is apt, therefore, to be deceptive. In averages the figures for CO are, say, 0·2 per cent. to 0·5 per cent., and in good cases 0·1 per cent. to 0·2 per cent., bad cases being over 1 per cent.

8. *Economisers.*—As already indicated in a previous article in Engineering, November 1, 1918 ("Exact Data on the Running of Steam Boiler Plants, No. 1, Economisers"), the average saving in practice due to economisers is nothing like so great as commonly imagined, averaging about 11 per cent. of the coal bill instead of 15 per cent. to 20 per cent. as usually stated by economiser makers. For the "Lancashire" boiler plants to-day of four boilers, 30 ft. × 8 ft., 320 tubes, 9 ft. tubes may be regarded as representing average practice, corresponding to 11 per cent. saving in the coal bill and raising the feed water from 110 deg. F. to 230 deg. F. As previously stated, in calculating the saving, roughly 11 deg. F., rise in the feed water corresponds to 1 per cent. saving in the coal bill. On individual plants the usual custom is to instal 72, 96 or 120 tubes per boiler. The installation of economisers chokes the draught in the case of chimney draught, because of the reduction in the temperature of the gases at the chimney base. Thus, taking a typical case of a chimney 170 ft. high with gases 600 deg. F., in the base giving 1·14 in. water gauge at the chimney base, if economisers are installed and the flue gases reduced in temperature to 350 deg. F., the draught would then only be, say, 0·70 in. water gauge. In a plant run on the most up-to-date lines the saving can average 18 per cent. to 20 per cent., and 17½ per cent. can be taken as a fair average figure for a good economiser installation even if modern scientific methods of control are not adopted throughout.

9. *Superheaters.*—Expressed as averages the ordinary "Lancashire" boiler plant can be stated to be working without superheaters, and the boiler plants of Great Britain make very little use of superheating. When installed a rough calculation is, say, 0·05 per cent. saving in the coal bill for every 1 deg. F. rise in the temperature of the steam above saturation point. A plant on modern lines will superheat the steam to, say, 170 deg. F. to

200 deg. F. above saturation point, and reduce the coal bill 9 per cent. to 10 per cent. in addition, of course, to the extra efficiency in the engine or turbine.

10. *Steam or Power used as Auxiliary to the Production of Steam.*—As already pointed out in a previous paper in ENGINEERING, January 16, 1920 ("Exact Data on the Running of Steam Boiler Plants, No. 3, the Amount of Steam Used by Steam Jets"), the amount of steam used by steam jets is much greater than is commonly supposed. The average figure was found to be 6·6 per cent. of the steam production of the plant, being the same for both mechanical stokers and hand-fired steam-jet furnaces, the general impression being that it is only about 1 per cent. to 2 per cent. On individual plants the figure may be anything from 0·5 per cent. to 20 per cent. Mechanical forced, or induced, draught generally takes about 2½ per cent. of the production at full output. As we have no proper engineering census it is difficult to give average figures for auxiliary steam or power consumption, because it is not known what proportion of the boiler plants of the country use such apparatus. I estimate roughly that the figure is 35 per cent. of the plants of Great Britain, and 2½ per cent. for the whole of the plants of the country is probably not far wrong. I have taken the bad plant as 5 per cent., and 2½ per cent. would still be required by the most up-to-date plant. Naturally, in calculating the net working efficiency of a boiler plant such steam has to be deducted as it is not useful steam.

11. *Efficiency of Plant.*—In averages a "Lancashire" boiler plant is working at, say, 54½ per cent. for the boilers only, and 60 per cent. for the whole plant, including economisers and deducting 2½ per cent. for the auxiliary steam. Bad plants may be about 50 per cent. net working efficiency. This is very much less than is commonly supposed, the usual empirical figures in general use corresponding to about 75 per cent. net working efficiency, which is entirely erroneous. A modern plant will give about 58 per cent. efficiency on the boiler only, corresponding to about 77¼ per cent. net working efficiency, although individual "Lancashire" boiler plants can be worked at 80 per cent. net working efficiency. This, as seen, includes the full use of economisers and superheaters, but allowing also for mechanical draught with the consequent 2½ per cent. auxiliary steam required to drive the fan.

(To be continued.)

THE SHIPBUILDING, ENGINEERING AND ELECTRICAL EXHIBITION AT GLASGOW.

(Concluded from page 733.)

ALTHOUGH we have endeavoured either in our preceding articles, or in this our final one, to deal with the majority of the important and interesting exhibits which were to be seen at the Glasgow Show, it will be evident that we cannot pretend to have dealt with every article on view, or with every stand. Certain of the exhibits we may find it desirable to deal with independently in our columns in the near future, while others we have simply had to refrain from touching on owing to lack of space. We have, however, devoted a considerable number of columns, spread over five weeks, to this important exhibition, and think we may claim to have done it full justice. The various exhibits which we still have to describe are of a somewhat varied nature, and we shall not make an impossible attempt to deal with them in any way in groups or common sections. The order in which we take them is to some extent fortuitous.

We may begin with an ingenious and useful little machine intended for slotting condenser ferrules, which was shown by Messrs. W. Crockatt and Sons, Limited, of 64, Darnley-street, Glasgow, and illustrated in Fig. 47 on this page. The machine, which is made by Messrs. Bromell Patents Company, Limited, of the same address, was described by Mr. Hamilton Gibson in his paper read before the Institute of Marine Engineers last March. This paper was reprinted in our issue of May 21 last. In his paper, Mr. Gibson dealt with an early model of the machine, but it has now been entirely redesigned for manufacturing purposes and, as will be seen from our engraving, makes a pleasing and workmanlike-looking job. The operation of the machine is very simple. As will be seen, it consists of a slotting saw and a revolving disc wheel with radial holes in the rim. The ferrules to be slotted are placed in these holes and are in turn brought under the action of the saw.

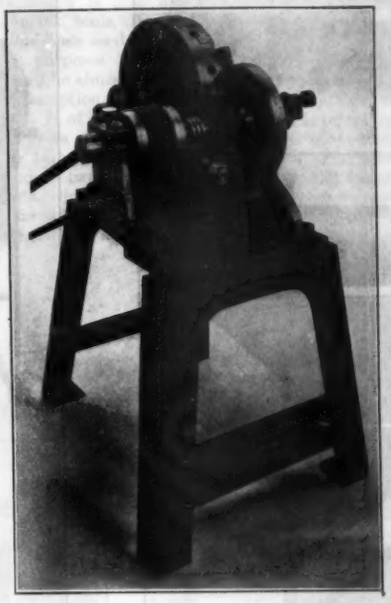


FIG. 47. FERRULE SLOTTING MACHINE; MESSRS. W. CROCKATT AND SONS, LTD.

FIG. 48. ELECTRIC SEAM WELDER; MESSRS. MARRYAT AND PLACE, LTD.

One side of each radial hole is formed by a sliding grip, which is normally held in the outward position by a spring, but when each hole in turn approaches the saw the grip comes in contact with a fixed cam-plate on the frame. This causes it to move inward and grip the ferrule while it is being slotted. After passing the saw the grip opens and the ferrule falls into a receptacle below the machine. There are 12 ferrule-holders on the wheel, and it makes three revolutions a minute, so that something over 2,000 ferrules an hour can be slotted.

In Fig. 48 we illustrate an electric seam welder of a type which was shown by Messrs. Marryat and Place, of 28 Hatton Garden, London, E.C. 1. This machine works on an intermittent cycle as distinct from the continuous welding which is common with this form of machine. The work is gripped between rollers, as is usual, and these rollers conduct the current to the joint which is to be fused. Instead of the work being continually fed forward, however, it is fed in a series of steps and the circuit is broken and extra mechanical pressure brought to bear on the weld by the rollers at each step. In starting a weld the rollers are brought together on the work by a foot pedal and as soon as they come down on to it the circuit is made. This causes the two parts of the joint to fuse together, but before the work is moved on to continue the seam the current is switched off and extra mechanical pressure brought to bear by the rollers, as we have already stated. After each weld of this kind a short, but sufficient, period is allowed for the weld to cool-off and set, before the rollers move.

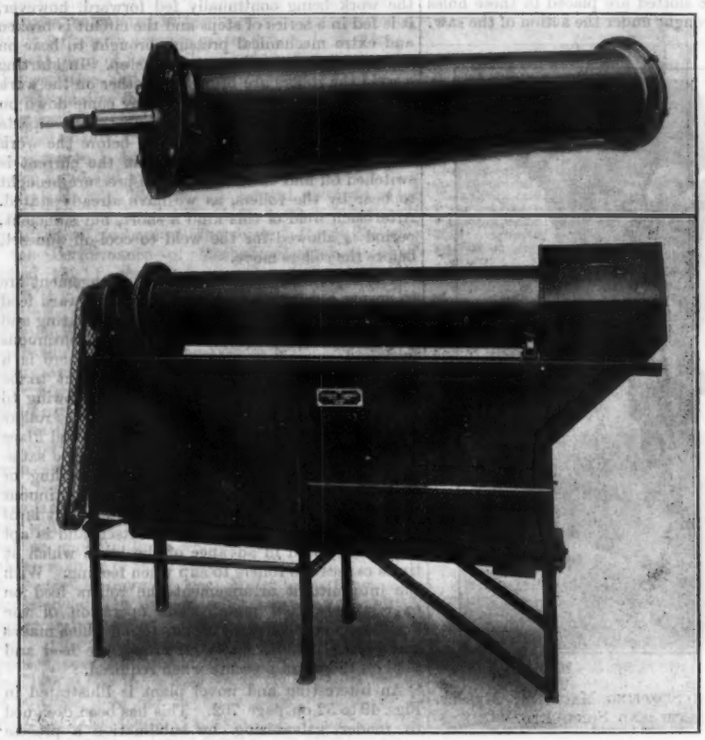
The objects of this intermittent arrangement are to ensure a more uniform and certain forward feed of the work and the elimination of overheating and burning of the roller electrodes. With a continuous feed and current flowing all the time there is a tendency for the welded part of the joint to be left in a plastic condition by the rollers owing to insufficient time for cooling down. The rollers also become very hot. With the Marryat and Place machine it is stated that sheet iron may be satisfactorily welded without preliminary pickling or sand-blasting of the material. With continuous welding the scale is apt to give trouble as it is of lower melting-point than the iron itself and is apt to become fused in advance of the joint, which at times causes the rollers to slip when feeding. With the intermittent arrangement the rollers feed on to relatively cold metal. The operation of the machine is controlled by a cam action which makes and breaks circuit, starts, or stops, the feed and puts on the extra pressure when required.

An interesting and novel plant is illustrated in Figs. 49 to 52 on page 762. This has been designed to render galvanising by sublimation a process capable of being carried out by unskilled labour with regularity and certainty. The operations involved in the working of the plant are simple and a high-class product is produced. The plant is manufactured by the Galvanizing Equipment Company, Limited, of 29A, Portpool-lane, Gray's Inn-road, London, E.C.1, and various samples of work produced by the plant were to be seen on the company's stand at Glasgow. They were of a high order of excellence, the coating on the metal being uniform and smooth without either breaks or surplus metal and a very pleasing finish was obtained. The plant we illustrate is designed for working in conjunction with the "Galeco" process of galvanising, or rust proofing. This process consists in treating the articles to be coated in a container placed in a furnace and in conjunction with the company's special compound. We have no detail of the composition of this, but understand that it is not merely zinc, but is some form of alloy. It is claimed that the coating of this alloy which is formed on the articles treated, affords greater resistance to corrosion than zinc and forms an absolutely continuous coating. It certainly is of admirable appearance, and appears to absolutely cover such articles as wood screws without the thread being clogged in any way.

Much interest lies in the plant from the point of view of the simplicity of the operations involved in its working and the fact that no skilled labour is required. The articles to be treated are placed in the hollow cylinder shown in Fig. 49 along with a charge of the galvanising compound. The end covers of the container carry trunnion shafts as will be seen, and the whole arrangement after charging is placed in the furnace shown in Fig. 52. In this the container is rotated by the gearing shown, the trunnion shaft at the right-hand end being slotted to engage with a dog clutch. The furnace, as will be seen, is a self-contained metal structure. The flue is at the back side and the furnace is lined with asbestos and firebrick. The furnace is charged with coke, and combustion is maintained by a series of air nozzles which are coupled up to a fan. The upper cover of the furnace is hinged and is lifted

to insert or remove a container, but it remains lowered as shown in the figure during working. In order that the progress of the articles being treated may be tested without having to interfere with or open the container, the left-hand trunnion is made hollow and carries a test rod. This may be seen in Fig. 49. This rod projects about 9 in. into the container. At the free end of the trunnion a gland is provided and a detent to prevent the rod being unintentionally withdrawn. To inspect the progress of the rust-proofing the detent is lifted and the rod withdrawn until the part which was inside the container lies within the hollow trunnion. It is left in this position for a few minutes to cool and then is further withdrawn for inspection of the coating, but the rod cannot be completely withdrawn accidentally and so open a passage to the interior of the container.

Our remaining two illustrations, Figs. 50 and 51, show the separating machine, in which the treated articles are automatically separated from the galvanising compound. The container shown on this machine is the same one which is used in the furnace, the complete charged container after treatment being lifted by a portable gib crane, or an overhead runway, and placed on the separating machine. When on this machine the cover is removed from one end of the container and this end lies in a hood, the container being supported on castors. The other end of the container is carried on a bearing as before and the driving gear shown causes the container to rotate slowly. As the container lies at a slight angle this rotation causes the contents to be fed into a chute, which can be seen below the hood in Fig. 50. The body of the separating machine carries a rotating sieve drum and the chute feeds the material into it. This separates the compound from the treated articles, the former falling on to a worm conveyor and being collected for further use. The finished articles emerge at the opening between the small sprocket wheels shown in Fig. 51. It will be understood, of course, that the plant may be practically continually operating. Several containers are used even with one furnace and separating machine, so that one is being charged while another is being treated, and so on. A plant with five 20 cwt. containers can be operated by two men. Two horse-power are required for driving, and 3 cwt. of coke would be burned in an eight-hour day.]



FIGS. 49 AND 50.

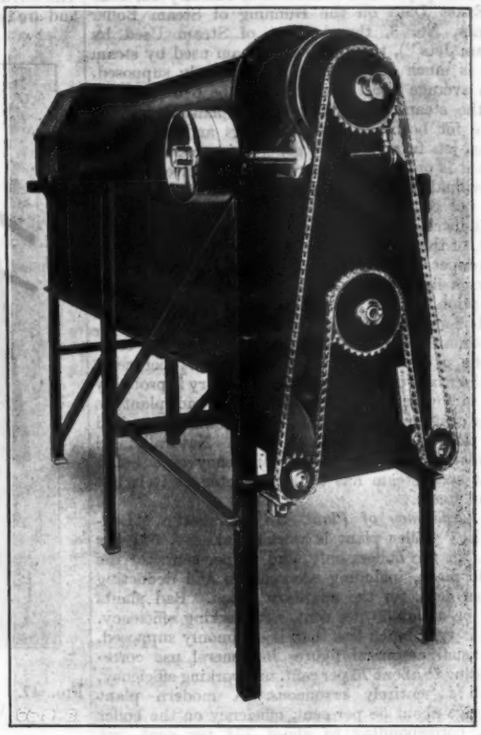


FIG. 51.

FIGS. 49 TO 51. CONTAINER AND SEPARATING MACHINE FOR GALVANISING PLANT; THE GALVANISING EQUIPMENT COMPANY, LTD.

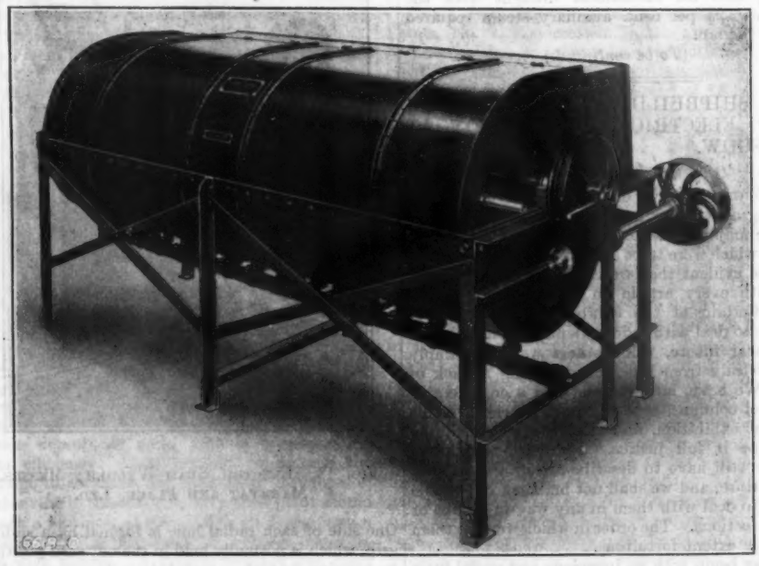


FIG. 52. FURNACE FOR GALVANISING PLANT; THE GALVANISING EQUIPMENT COMPANY, LTD.

In earlier articles we have dealt with a number of the hot-bulb engines which were shown at Glasgow. We have also illustrated and described one of the paraffin, or petrol, engines which were on view. This latter class was represented by a number of firms, and in Figs. 53 and 54, on page 763, we illustrate another interesting example. This is a four-cylinder, 4-in. by 5-in., petrol, or paraffin, marine engine with reverse gear. It is built by Messrs. The Atlantic Engine Company (1920), Limited, of Wishaw, Scotland. The engine runs at 1,000 r.p.m., and develops 17 h.p. on paraffin and 20 h.p. on petrol. No great novelty has been aimed at in this engine, the object of the design being rather the production of a model accessible in all its parts and likely to give steady and efficient service in use. The engine, as were all of those exhibited by the firm, is of excellent appearance, and shows every evidence of a good class of workmanship. The chief novelty of the engine lies in the water-cooling arrangement, which is

used in connection with the lubricating oil, but before describing this we may refer briefly to some of the main constructional features. The crankshaft is in one piece and is carried in three bearings which are supported in the lower half of the crank-case. The camshaft and magneto are driven from the forward end of the crankshaft, the governor being fitted in a very accessible position on the shaft which drives the magneto, and the whole arrangement making a very straightforward lay-out. The water-circulating pump is of the plunger type driven by an eccentric on the lay-shaft of the reverse gear. The cylinders are made in pairs, with loose heads, and each pair is fitted with a separate vapouriser, making in effect two independent engines. The camshaft is made in one piece from the solid, and is carried in gun-metal bushes of such diameter that it can be withdrawn without dismantling the engine. A Zenith carburettor is used. The reverse gear is of the double-cone type as is clearly shown in Fig. 53. It is operated by a quick-pitch screw.

Lubricating is by splash and, as will be seen from Fig. 53, a series of baffles are formed across the bottom of the crank-case forming a tank for each big-end. A duct is formed between the front and back ends of the crank-case, and while the engine is at work the splash of the big-ends causes the oil to be carried to the front or higher end, from where it flows down the crank-case over the baffles. The oil duct is enclosed in a water jacket, through which the supply to the cylinder jacket pump passes, so that the circulating oil is kept comparatively cool no matter how long the engine is at work. A drip feed is also supplied for giving a regular supply of fresh oil to the main bearings.

There was a good display of pneumatic tools to be seen at the exhibition, and most of the well-known firms were represented. These included the Ingersoll-Rand Company, of 20, Renfrew-street, Glasgow, who showed a compressor belt-driven from an electric motor, and a large range of their "Little David" tools; Messrs. Bristol Pneumatic Tools, of Fishponds, Bristol, who showed riveting and chipping hammers, pneumatic caulking tools, &c.; Messrs the Clement, Stevens Pneumatic Engineering Company, Limited, of 28, Spenser-street, Buckingham Gate, London, S.W. 1. The pneumatic tools of this company have a number of special features, and an illustrated description of their hammer appeared in our issue of October 3 of last year. Pneumatic tools were also shown by Messrs. John Macdonald and Co., of Pollokshaws, Glasgow, the Howard Pneumatic Engineering Company, Limited, of 11, Bothwell-street, Glasgow; and the Consolidated Pneumatic Tool Company, Limited, of Egyptian House, 170, Piccadilly, London, W. 1. In addition to a large range of pneumatic and electric tools of various kinds this firm also showed a new type of coupling for pneumatic hose which we illustrate in Fig. 55, subjoined.

The coupling is intended for use with flexible hose which is now almost universally used for pneumatic tools. It is also suitable for use with flexible hose used for the conveyance of oil or for other purposes. The coupling is a simple one, and will be almost understood from the figure without description. Three of its particular features are that it is of the metal-to-metal type, involves no loose parts and requires no spanners or other tools when being made up or disconnected. The joint is made between cone faces on the male and female spigots, while the two lengths of hose are secured on the spigots by the sleeves, the arrangement of which can be clearly seen in the figure. The sleeves

Fig. 53.

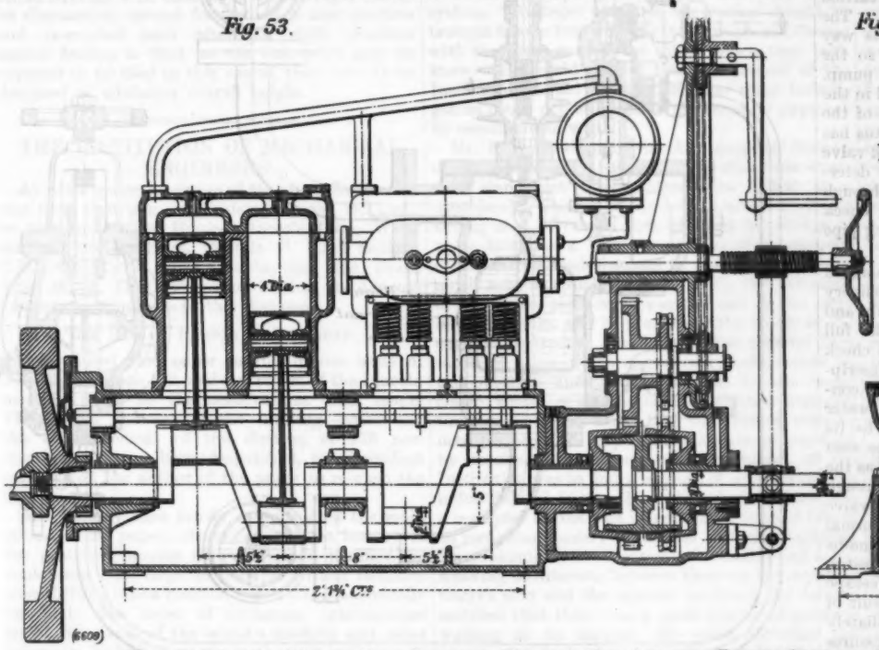
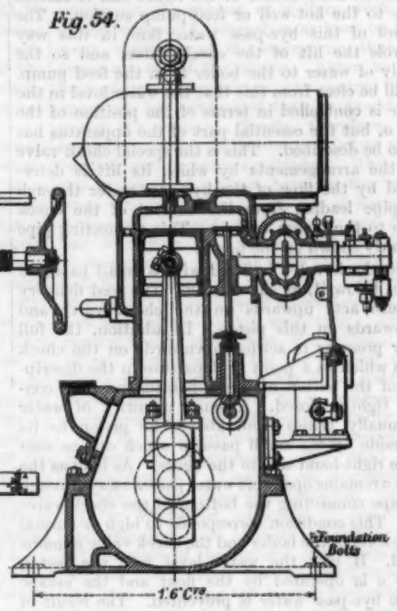


Fig. 54.



FIGS. 53 AND 54. MARINE TYPE PARAFFIN ENGINE; THE ATLANTIC ENGINE COMPANY (1920), LIMITED, WISHAW.

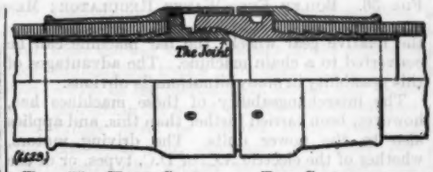


FIG. 55. HOSE COUPLING; THE CONSOLIDATED PNEUMATIC TOOL COMPANY, LTD.

press the rubber down tightly into the serrations on the spigots and prevent the hose from blowing or pulling off. The sleeves are locked against the spigots by grub screws after assembly. It will be clear from an inspection of the figure that the thread on the male spigot is entirely protected by the overhanging sleeve so that it is not damaged if the hose is thrown down or knocked against hard objects when in use. The female thread is of course protected by being inside its spigot. It is also evident that the bearing faces of the joint are similarly protected. The sleeves are knurled outside so that the coupling may be connected, or disconnected, by hand, and short threads are used, so that only a very small rotation of the hose is necessary. In large sizes a breech mechanism with slotted threads is used.

As we have already indicated we cannot pretend to deal with all the exhibits which were shown at Glasgow, but before concluding this last article we should like to refer briefly to the display of oil fuel burning apparatus which was made. Interesting stands were arranged by Messrs. J. Samuel White and Co., of East Cowes, Messrs. James Howden and Co., Limited, of 195, Scotland-street, Glasgow, and Messrs. Smiths Dock Company, Limited, of North Shields. The plant of most of these firms will be generally known, but one may refer to the neat alternative coal or oil-firing arrangement of the latter in which the oil burners are arranged at an angle on either side of the coal-firing door. With this lay-out the oil burners are well away from the coal-firing door, and a change-over from one type of fuel to the other may be made with the minimum of inconvenience.

We would also like to refer to the very extensive exhibit of electric and oxy-acetylene welding apparatus, as this formed a prominent feature of the show. This is, of course, a type of apparatus which does not lend itself to very effective display in an exhibition unless one arranges an actual welding demonstration like Messrs. Alloy Welding Processes, Limited, of 14–16, Cockspur-street, London, S.W. 1. An interesting collection of plant was, however, also to be seen on the stand of Messrs. The A.C. Cutting and Welding Company, Limited, of 25–27, Theobalds-road, London, W.C. 1. The rivet-heater shown by this firm we illustrated last week. They also exhibited welding machines, electrodes, &c. Messrs. The Quasi-Arc Company, Limited, of 3, Lawrence Pountney Hill, Cannon-street, E.C. 4, on whose system the all-welded ship Fullagar was built, showed typical joints, electrodes, &c., as did also Messrs. The Double Arc Electric Welders, Limited, of 26, India-street, Charing Cross, Glasgow. This firm has recently completed an interesting welding building for their own workshops, which we hope to illustrate in an early issue. A similar type of display was made by the North British Premier Electric Welding Company, Limited, of 2, Furneston Quay, Glasgow. Oxy-acetylene welding was represented by Messrs. Allen-Liversidge, Limited, of Milnbank Works, Alexandra Parade, Glasgow, who showed low-pressure generators for acetylene, cutting outfits, &c., the British Oxygen Company, Limited, of Rosehill Works, Polmadie, Glasgow, and the Oxy-Acetylene Welding Company, Limited, of 21A, St. Vincent-street, Finneston, Glasgow.

An interesting feed-water regulator for boilers which was shown by Messrs. W. Crockatt and Sons, Limited, of 64, Darnley-street, Glasgow, is illustrated in Fig. 56, on page 764. This device is known as the "Anthony" feed-water regulator, and is manufactured by Messrs. Robert Warner and Co. (Engineers), Limited, of Walton-on-the-Naze. This appliance, which was approved by the Admiralty for installation on standard ships

has no parts inside the boiler. It consists essentially of a float *a* working inside a closed chamber, the upper and lower parts of which are connected respectively to the steam and water spaces of the boiler. These connections will be obvious from Fig. 56. The float, as will be seen, is of the open type filled with water, so that there is no hollow sealed body subjected to boiler pressure. In order that the float may always remain full of water a small condenser *b* is fixed in the casing above it. This device causes a certain amount of condensation, and the resulting water trickles down into the float.

As will be seen from the figure the float is mounted on a balanced arm which is connected up to a piston valve *c*. This valve controls a bye-pass supply of water which comes from the boiler check valve shown to the right of Fig. 56. As the float rises or falls the valve *c* is operated, and this either opens or closes the passage through which the bye-pass water comes. When the passage is open this water escapes through the pipe shown in the upper left-hand corner of the figure and is carried away to the hot-well or feed-pump suction. The control of this bye-pass water flow in this way controls the lift of the check valve, and so the supply of water to the boiler from the feed pump. It will be clear from this that the water level in the boiler is controlled in terms of the position of the float *a*, but the essential part of the apparatus has yet to be described. This is the special check valve and the arrangements by which its lift is determined by the flow of the bye-pass water through the pipe leading from the bottom of the check valve to the piston valve *c*. This connecting pipe is clearly shown on the figure.

The check valve is fitted with a small balanced piston below it, as shown at *d*. The feed delivery pressure acts upwards on the check valve and downwards on this piston. In addition, the full boiler pressure is acting downwards on the check valve which as a point of departure in the description of the action of the apparatus we may consider tightly closed. A small quantity of water continually passes from above the piston to its underside by the small passage which can be seen at the right-hand side in the figure. As long as the valve *c* remains open this water passes away through the pipe connecting the bottom of the check valve to *c*. This condition corresponds to high or normal water level in the boiler and the check valve remains closed. If now the water level falls the piston valve *c* is operated by the float and the escape of the bye-pass water is prevented. The result of this is that the space below the piston *d* immediately fills up, so that the upward and downward pressures on the piston balance. The piston accordingly becomes inoperative, and the check valve is free to open under the feed pressure, and the feed water enters the boiler in the usual way. This state of affairs continues until the boiler water level has been restored to normal, when the valve *c* is again operated, the bye-pass water is freed and the check valve is again held down on its seat.

It will be seen that this boiler-feed regulator operates by controlling only a very small proportion (about 1 per cent.) of the total feed. This results in it being remarkably sensitive and operating very quickly. In a 22-hour official trial by the Admiralty with the regulator at the maker's works, the maximum variation of water level in the boiler did not exceed $\frac{1}{8}$ in. During this trial the boiler was run for a number of hours in each case at normal, high and low levels, and in no case did the maximum variation exceed that given. The variation of level can be controlled by the hand-wheel *f* shown above the float in Fig. 56. This hand-wheel, which works against an outside scale, controls the position of the float suspension and so regulates for different water levels. A final point which should be referred to is that a cock *e* is fitted below the check valve. By closing this cock the balance of the small piston is destroyed and the regulator is cut out. The arrangement may then operate as an ordinary check valve if desired.

A very complete display of colliery gear was made by Messrs. Mavor and Coulson, Limited, of 47, Broad-street, Mile End, Glasgow. This covered electric and compressed air coal cutters of the bar, chain and disc types, underground conveyors, protected motors, switchboards, &c. A series of illustrations showing some of this plant will be found on page 774. Figs. 57 to 60 show some of the firm's coal cutters. One of the most interesting features in connection with these machines is the system of standardisation and interchangeability which has been worked out. For instance, the bar and chain machines are identical, except for the cutting members, that is, the bar or chain and jib and the parts of the gear-head directly associated with them. It is thus possible readily to convert one type of machine to the other. This is illustrated in Figs. 59 and 60, from which it will be seen that by removing the lower part of the gear-head, or banjo, which carries the cutter bar, from the bar machine and substituting for it the corresponding part carrying the chain jib and chain and changing the relative gear wheels, the bar machine can be converted to a chain machine. The advantages of this possibility in many situations is obvious.

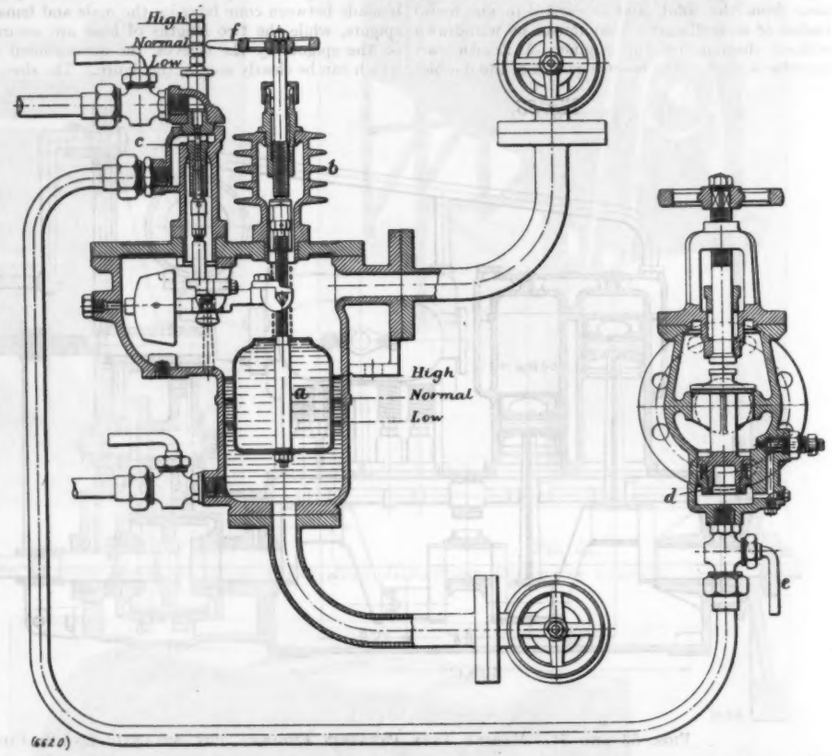


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FIG. 56. BOILER FEED-WATER REGULATOR; MESSRS. ROBERT WARNER AND CO. (ENGINEERS), LTD.

The interchangeability of these machines has, however, been carried further than this, and applies also to the power units. The driving motors, whether of the electric A.C. or D.C. types, or of the compressed air type, are all of the same external dimensions and occupy the same position in the structure of the machine. They are accordingly interchangeable, and a compressed air machine may be converted to an electric one, or *vice versa*. The starting switches and interconnections for the electric motor windings are contained in a common casing with the motor itself so that the whole arrangement may easily be placed in the machine. This possibility of converting compressed air machines to electric, or electric machines to compressed air, will obviously be of no service in collieries in which only one form of drive is employed, but in many cases, and especially in groups of collieries which use both forms of power, it will be a great convenience and will cut down the number of spares which have to be carried. The arrangement will clearly also have an important bearing on the cost of manufacture and as representing an example of standardisation is to be commended.

These coal cutters have been designed of moderate overall length, which facilitates their employment in various situations and for various types of working. They are fitted with a two-speed haulage gear operated from the motor. The slow and variable-speed haulage feeds the machine while it is cutting, and the high-speed haulage of 50 ft. a minute, is used to traverse the machine from heading to heading. The machines are mounted permanently on sledges and are hauled along the floor of the roadways, no flitting trucks being used. This arrangements adds greatly to the mobility of the machines and enables them to be taken from roadway to roadway with ease, or to be used, for instance, for driving several headings, the machine moving to another heading while the coal cut in an earlier one is being stripped. The second heading would be undercut while this work was going on, and, after a suitable distance had been cut, the machine could readily return to the first heading to continue the work. In connection with Messrs. Mavor and Coulson's disc machines, it should be said that a special feature is the disengaging arrangement, by means of which the cutter wheel may be disconnected from the gearing and may remain at rest while the motor is running.

Our remaining illustrations, Figs. 61 and 62, show the underground shaker and band conveyors which were exhibited by the firm. Underground conveyors of these types are used for conveying the coal from the working face to the loading road, and their employment not only increases the output per man, but reduces working costs, as fewer "gate roads" are required. The shaker conveyor, the driving mechanism of which is illustrated in our figure, is of very simple construction. It consists essentially of a shallow trough, supported on rollers and bolted together in convenient lengths for transport. It extends the full length of the face, which is usually about 100 yards. The rollers run on short iron tracks, which are curved and inclined to impart an up-and-down movement to the trough simultaneously with the to-and-fro shaking movement, which is contributed by gear of the type shown in Fig. 61. This combined movement, assisted by the gradient, causes the coal to move forward in the trough. The gear which provides the shaking motion may, of course, be driven either by an electric or compressed air motor.

The band conveyor, which is used for the same

service as the shaker conveyor, extends the full length of the face and consists of an endless textile band, usually about 20 in. wide, and made up in lengths of 25 yards for convenience in transport. The driving gear is situated at the discharging end of the conveyor, that is, on the loading road, and the tension gear is at the other end and is anchored to pit props. The belt is supported by intermediate rollers carried on light steel frames at intervals of from 7 ft. to 9 ft. Band conveyors of this type are somewhat more expensive than shaker conveyors both in first cost and upkeep, but have some advantages. One of these is that they work better on the level, a shaker conveyor giving best service when working on an inclined seam. The belt conveyor also has the advantage that it is reversible and can be used to carry pit props and other material to the working face. Conveyors of these and other types for underground working present some problems which are not met with in surface conveyors. Thus, as the coal face advances on an average 4 ft. each day, the conveyor has to be dismantled, moved forward to a new position and re-erected each afternoon shift. Another special feature is that, as the conveyors may be required to be used in thin seams, they have to be designed of minimum overall height.

THE INSTITUTION OF MECHANICAL ENGINEERS.

AN extra general meeting of the above Institution was held at 6 p.m. on Friday last, the 3rd inst., at the Institution House, Storey's Gate, Westminster, the president, Captain H. Riall Sankey, C.B., C.B.E., R.E.(ret.), occupying the chair, when Mr. A. Ramsay's paper, read at the Lincoln summer meeting, was further discussed.

THE HUMAN FACTOR IN INDUSTRY.

We printed this paper in full in our issue of July 23 last, page 132, and our report of the Lincoln meeting refers to the observations then made. The formal business of the meeting—embracing the announcement of the election of 136 new members—having been despatched, the President called upon the author of the paper to re-open the discussion.

Mr. Ramsay then briefly recapitulated the main points of his paper, observing that the history of the past few months had more than justified his contention that large sections of British industry were drifting into a position which was economically unsound. The rates of exchange, international credit, the state of the world's markets and other influences had their origin in the cost and volume of production. In quite recent years the most strenuous argument put forward by the workers turned upon the cost of living. It was ridiculous to think that we could export high-priced articles and receive cheap ones in return. We formerly sent coal to the Argentine in return for wheat, but the price of the coal rose to such an extent as to make it cheaper in South America to buy coal from North America. Now ships were sent in ballast to bring wheat from the Argentine, the wheat bearing the double freightage cost. A state of comfort was now demanded which could only be attained by hard work and excellent organisation. It was clear that we could not consume unless we produced. The employer should make it clear that he desires to give to the worker the comfort he may reasonably expect. The best minds of the country should address themselves to the closing of the chasm between the employer and the employed, which otherwise must widen.

The President agreed that co-operation between employers and employed was essential to salvation, and personally he felt that the Institution could do something to help on the desired end.

Colonel David Carnegie, C.B.E., F.R.S.E., said that as a member of the Ordnance Advisory Committee of the Imperial Munitions Board, he had an opportunity of dealing with the various phases of industry throughout Canada. Since the termination of hostilities he had, on behalf of the Canadian Government, investigated the industrial situation in this country, in order to ascertain how far joint industrial councils could be applied to the industries in Canada. Mr. Ramsay had remarked, in his paper, that most of the great trade unions of the country had declared against working a system of payment by result. He thought that most of the trade unions of the country were not opposed to the principle of payment by result, but to those imperfect systems now in use which embodied the principle. Mr. Ramsay had gone on to say "in spite of the most complete safeguard for the inefficient." He (the speaker) considered that in the existing conflict between employer and employed, the insecurity of the inefficient was the rock upon which many of the best schemes had foundered. What were the safeguards of the worker against the prices of piece work, individual or collective, being cut? Where had the worker a voice in determining the prices? The worker should have a safeguard against a breakdown of the contract from the other side. A system having relation to payment by results would bring the best out of a worker and increase production in the best way; he believed it would bring prosperity sooner than any other system. To dispel suspicion the worker should be brought face to face with the facts and should discuss with the management the things which they both knew. He would suggest that the Council of the Institution should consider whether some investigation could not be made of the terms of payment by result now in vogue.

Mr. F. S. Button, of the Amalgamated Society of Engineers, said it seemed to him that from whatever standpoint the problem were looked at a considerable amount of agreement would be found among men of reason, foresight and knowledge of up-to-date affairs. On the question of the attitude of the skilled trades unions to payment by results much misconception existed. With the exception of Liverpool, piece-work was the rule in the shipbuilding trade, and in practically the whole of the engineering trade. A ballot vote had recently been taken of some of the engineering trade unions on this question, and the issue was not by any means clear. Speaking as a mechanical operative engineer, there could be no doubt that the average working man preferred to be paid on a system of payment by results. The object, as he assumed, of the Institution was to find a way out of what seemed an industrial *cul-de-sac*. He believed that there was a readiness on the part of certain sections of labour to recognise identity of interest with the capitalist. There should be no essential lack of unity and interweaving of interests between those on the administrative side and the manual workers; for he was satisfied that there was a great reserve of goodwill waiting to be tapped. He could therefore not imagine any body of men more likely to be influential in finding a *via media* than the Council of the Institution. No trade unionist of standing would defend the policy of "ca' canny." Rehabilitation after the war was dependent on the engineering and shipbuilding trades more than on any other, and it would be impracticable to rebuild and improve our position in the world unless we produced more. The things must be created before they could be possessed, and, obviously, the more the goods created the greater the reserve upon which to draw.

There was a feeling to-day that industry was on a onesided basis, and that its constitution was wrong. The main argument among extremists, shop stewards and potential Bolsheviks, was this, that the working man was a mere hanger-on, without any absolute or final independence. Conclusions of that kind were not reached by considerable bodies of men without some justification. Many people believed that the working man was unfit for the office of director, and they contended that the worker should prove his title to power by acting responsibly with the power he already possessed. He could on that point urge that it was unreasonable to expect that men who, speaking metaphorically, had lived their lives in a cave, would not blink on coming into the sunlight. He felt that great power accrued to the working man who sat day by day, cheek by jowl, with the employer on Whitley Councils, dealing with everyday problems. Mr. Button had no despair of the great potentialities of the working man if a chance were given to him to prove his value to industry and to the State. What was needed was that the worker should be given a more assured position and a higher status in industry, together with opportunity to rise from the bottom to the top, so that every apprentice was a potential director. He had this already in the social and political world. Once an appeal were made to him as a man, and a chance given him to share responsibility, much would be done to remove the existing mistrust and the policy of restricting output.

Mr. Robert R. Hyde, of the Industrial Welfare Society, was the next speaker. He said the author had alluded to the chasm between employer and employed. How was that chasm to be filled up? Many urged that the recognition of the human factor in industry could be dealt with by co-partnership, profit-sharing, bonuses, collective piecework; but such schemes wanted some foundation upon just human relationships. The worker regarded the employer as standing between him and his rightful aspirations. On the other hand, the employer blamed the workman for many industrial difficulties. He had recently addressed coal-owners on the subject of welfare work, and the owners expressed themselves as keen on the movement, observing at the same time, that he would never get round the miners. Later, he had similarly addressed the miners, who assured him of their approval, but contended that he would never get round the owners. Clearly, therefore, there was misunderstanding to be removed before any scheme could be satisfactorily established. This was partly due to want of contact between the two. Even when contact existed it was not of the right kind; it was rather hostile than friendly and close. The last four years had shown such helpful contact to be possible. In some cases the personal element had been introduced by proxy. The engagement of a worker could be made a useful means of showing personal interest in his well-being. Questions of general health, of accident, of conditions of working offered opportunities for the display of interest. There were now about 200 firms publishing and maintaining their own house magazine. These could greatly assist in fostering friendly relations.

Mr. H. M. Rounthwaite thought something might be done by propaganda. But what description of propaganda? Treatises on economics were unsuitable. The, otherwise excellent, work written by Dr. Wicksteed, extended to some 700 pages, and required close thought to follow adequately. At the time of the Reform Bill, when the outlook seemed black, Miss Harriet Martineau conceived the idea of putting the leading elementary facts of economics into the form of short stories, and, in spite of dissuasion, published in 1831 her "Illustrations of Political Economy." Five thousand copies were sold within a fortnight. Whether read by the working man or not, they showed one method of setting to work. He would suggest that employers should unite to secure the services of skilled writers of the social essay. The Institution could not, as a body, legally devote money to the purpose.

Mr. W. Dent Priestman, of Priestman Brothers, Hull, remarked that he had for very many years been interested in questions affecting workmen, and had a strong belief that from every human being something was to be gained by proper handling. He had every confidence in the successful issue of the attempt to bridge the chasm between master and man existed. His firm, as employers, had taken counsel with the men, and secured their approval of a scheme whereby, in return for a percentage of increase in output, they would receive the same percentage of increase on the standard or base wage, plus an additional 10 per cent. to the standard rate for giving it a trial. The workmen considered the proposal as almost too good to be true. The foremen and unions were consulted, and the scheme set going. The firm met the shop committee every month, and stated the excess over standard. As a result the workmen were now getting something like 50 per cent. above their base wage for about 40 per cent. increase in output in tons, the promised 10 per cent. being added to the pay. The speaker anticipated that next week the workers would be apprised of a 50 per cent. increase output, as compared with pre-scheme days, resulting in a 60 per cent. advance on the standard wage. As a result of the working of the system the relations between

the firm and their men were friendly, and the latter were satisfied with the return they gained by their extra work. The scheme had been in operation for several years, without modification. He had feared a possible desire on the part of the workmen to come in as managers, but after four years there had been no suggestion of that; the men were contented with a reasonable return for extra work.

Mr. E. Holden, of Messrs. Ruston and Hornsby, Ltd., said the question under discussion could be summed up in one word, "co-operation." He would ask the attention of the meeting to two aspects, one of which was industrial welfare, already discussed. He belonged to the order of persons who might be termed "trouble removers." It was necessary to adopt welfare work as a definite line of conduct. Definite action had been taken in the training of officers for the work. Practically every university in the British Isles had in operation a scheme of training for welfare workers. The welfare worker was a functional manager. The second aspect related to education, and he put forward seriously the suggestion that the Institution would consider what steps could be taken to help the needs of the young engineer in the provinces. The new Education Act would give the young engineer a general outlook on life upon lines similar to those of the employers. This would give him a different angle of vision in regard to work.

Mr. J. E. Powell, the next speaker, observed that Mr. Ramsay had argued that the country had become accustomed to prodigal expenditure of wealth without particular scrutiny of the value received. With a little different interpretation, the words were true. The speaker's experience had forced upon him the conclusion that all the blame did not attach to the worker. It was not, the speaker thought, to be wondered at that the output reflected the policy of obtaining from the worker the utmost production at the lowest pay, while obtaining from the employer the highest pay for the least work. That factor in the situation was not adequately recognised.

Mr. A. E. Thurston laid stress upon introducing into the labour question something of the spirit of service manifested during the war, the spirit in which a man was willing to neglect his own adversities while taking an interest in those of others. It was, among other things, necessary to take time to explain matters, *i.e.*, the difficulties to be overcome and the steps taken to overcome them. Such action, he contended, would produce whole-hearted support.

Mr. E. T. Elbourne observed that the three elements in the subject of the paper were finance, management and labour. The manager of a works occupied a special position as the steward of capital and director of labour. Without personal contact, there was no sure foundation for goodwill. Rather than "co-operation" the speaker would suggest "co-ordination" as most favourable to personal contact. A co-ordination committee, to which was attached a works investigation officer, might do a lot of good. By this medium the meaning of things was explained by one side to the other, and the troubles consequent on misunderstandings could thus be removed.

Mr. W. H. Patchell congratulated the Institution on facing the matter frankly. In New York recently he had attended the fortieth anniversary of the American Society of Mechanical Engineers. The text of the evening was, the opportunity and responsibility of the engineer. He would quote as follows from the speech of Mr. Gompers: "I see before the labour movement a great future, but I also see a great future before the engineering profession, if the engineer should join hands with the workman, but devoting their energy to one cause, namely, the development of the kind of industry and the kind of work in which the men will not only learn the processes of production, but each day will have increasing opportunities to develop those human functions which are essentially imperative." Mr. Patchell considered the foregoing remark to sum up the case closely. All that was wanted was goodwill and intelligent co-operation from both sides.

Mr. Alexander Ramsay then replied to the discussion. Colonel Carnegie appeared, he thought, to have taken his evidence from one side only. Agreements had been made relative to payments by results on a national basis. These agreements provided that all payments should be fixed on such a basis as would permit a man to earn 33⅓ per cent. of his time wage. Moreover, every agreement entered into provided that under no circumstances should a man earn less than his day rate of wages. He would suggest that that was security for the inefficient, and he could not conceive of any security more reliable. That the working lad did not have the opportunity to which he was entitled was a general statement, which went too far. In Scotland it was possible for a boy of the humblest parentage to go right through school and university and attain the highest position, if he had the necessary gifts. With regard to Mr. Hyde's remarks, undoubtedly welfare was, especially among young people, one of the hopes of the industrial future. The very human way in which Mr. Rounthwaite and Mr. Priestman had handled these problems deserved a great deal of attention. Those who were responsible for the development of organised labour were definitely joining issue with employers on the principle of their organisation, and, while personal contact and administration as a whole were of importance, it was of higher importance that those who believed in the present organisation should justify that organisation lest worse befall.

The meeting was then terminated, the President announcing that the next meeting would be held on Friday, December 17, at 6 p.m., when a paper on "Thermodynamic Cycles in Relation to the Design and Future Development of Internal-Combustion Motors," by Mr. William J. Walker, of Manchester, would be read.

Turret Lathe Practice.—A lecture was given before the Peterborough Engineering Society, on Saturday, November 27, by Mr. A. H. Lloyd, of Messrs. Alfred Herbert, Limited, Coventry, on "Tooling the Modern Turret Lathe." The author, after dealing with some of the pre-war prejudices against turret lathes, went fully into the question of designing turret-lathe tool lay-outs, explaining by means of lantern slides a number of typical examples of modern practice. Mr. Lloyd dealt both with plain chuck work, the chucking of work of irregular contour, the use of fixtures in place of chucks, and so on. The whole subject was very lucidly explained and liberally illustrated. The meeting, which was held in the Lecture Hall of the Municipal Technical School, was presided over by Mr. C. W. Bryant.

The United States' Wooden Vessels.—A Swedish consular report deals with the difficulty which the United States Shipping Board are experiencing in disposing of their wooden vessels, the total number of which amounts to 406, of different types. Twenty-one vessels with an aggregate deadweight tonnage of 82,000 have recently been offered for sale, but were not sold. The vessels in service number 194, whilst 73 are lying idle in different ports, and 139 have been transferred to the storage yards. Of the latter, 107 are hulls and 32 altered sloops. The aggregate production of the Shipping Board during the war amounted to 532 vessels, of which 114, with an aggregate deadweight tonnage of 397,285 have been disposed of, whilst 12 vessels totalling 44,546 tons deadweight have been lost. It has been calculated that if the Shipping Board can dispose of the remaining vessels at 90 dols. per ton, the total loss to the United States Government on these ships will be about 170,000,000. At a recent sale by auction 283 wooden vessels were offered for sale, but bids, amounting only to 116,000 dols., were received for 4 vessels with an aggregate deadweight tonnage of 14,000.

Electric Furnace Progress.—The use of electric furnaces for melting and refining continues to expand, says *The Iron Age*, New York. This is particularly true in the non-ferrous metal industries. In a period of only six months, or from March to September of this year, the number of furnaces installed or contracted for at works in the United States and Canada increased from 261 to 385, or by 47·5 per cent. There are now more furnaces in the non-ferrous than in the steel industry—385 as compared with 374. It is of interest to note that in the non-ferrous industry about 33 per cent. of the furnaces are engaged in foundry operations, as against 50 per cent. in the steel industry. It was in the steel foundry that the electric furnace gained its first foothold in American steel-making. While electric steel-making has passed through the stage of spectacular development, this is probably not true of the non-ferrous field. It is evident at the same time that the use of electricity is about to take a wider range in the steel industry. Further, the results already obtained in the production of electric iron castings give promise of a wide application in the future. Still more interesting are developments in the application of the electric furnace to the chemical industry. Already some chemical reactions that have depended on coal or other fuel are being commercially and successfully carried out in special electric furnaces. A wider use is predicted for electricity in industrial chemistry with results that will be surprising as they develop.

5¼-IN. TOOL ROOM LATHE.

A very interesting light tool-room lathe has recently been brought out by Messrs. Harry F. Atkins, Limited, Old Fletton, Peterborough. This we illustrate in Figs. 1 to 5 on the opposite page, a general view of the machine being given in Fig. 5, while the remaining illustrations relate to the saddle and apron in which some unique details are to be found.

The lathe has 5¼ in. centres, with a length of bed of 5 ft., and raised inverted vees 9 in. apart for the saddle and heads. The fast headstock is fitted with a three-step cone, the spindle being bored to 1 in. The back gear ratio is 6¼ to 1. Twelve speeds are obtainable as the countershaft is fitted with two speeds. The spindle nose is a combination of screw and taper. The lead screw will be seen to be fitted exceptionally close up under the front shear. It has six threads to the inch, and with change gears can be used for all the usual English and metric threads. A pitch indicator is fitted on the saddle, and is to be seen at the left-hand upper corner of the elevation of the apron in Fig. 2. This shows the moment at which the lead screw should be engaged for any given pitch. An idler is used in the change gear train for cutting left-handed threads, thus abolishing the more usual tumbler arrangement. The feed spindle is belt-driven from the main spindle, and has four speeds. Two of these speeds are obtained off the small two-step belt pulleys and the other two by a two-speed clutch on the feed spindle below the headstock, these being thrown in and out by a short handle below the lead screw, working a sliding key.

Details of the saddle and apron may be followed from Figs. 1 to 4, the latter giving a view of the back side of the apron casting. The lead screw is engaged by a nut worked by the short handle in the upper portion of Figs. 1 and 2. Fig. 1 is an off-set section taken partly through this and partly through the centre of the hand-wheel spindle. Fig. 3 is again an off-set section taken partly through the cross traverse screw, and partly through the centre of the large worm and gear wheels shown in Figs. 2 and 4. The most interesting feature of the apron is the manner in which the drive is transmitted from the feed spindle. The spindle has a sliding sleeve fitting over it, which is driven by a key sliding in a slot in the spindle. At one end the sleeve is fitted with a circular rack, and at the other end with two short cones and a Vee groove. The central portion of the sleeve is plain, but at either end of it, inside the parts just described, are short lengths of right and left-handed worms. The sleeve can be racked either to the right or left by means of the handle and small pinion to be seen at the right hand of Fig. 2, the pinion being again visible at the left hand of Fig. 3. Supposing first the sleeve be racked to the right, the spring stop is first of all raised out of the centre groove at the left-hand end, and the worm at this end is brought into gear with the small worm wheel on the hand-wheel spindle, Fig. 1. The spring stop slips into position when the sleeve has been moved the correct distance. The worm wheel is free to revolve on this spindle, but engages, by a spring and dog, a pinion keyed to the spindle. The latter gears with the large toothed wheel shown as the outer wheel of the two depicted in section in Fig. 3. This, it will be seen, is keyed to the spindle on which it is centred, and which at its inner extremity has a small pinion engaging with the feed rack arranged directly under the front Vee way. The saddle is thus traversed by power. When traversing by hand the sleeve on the feed spindle is in neutral, and the hand-wheel is used direct, in the ordinary way.

If the sleeve is racked in the opposite direction, *i.e.*, to the left, Fig. 2, the spring stop again comes into play, and holds it in position for the worm at the right-hand end of the sleeve to engage direct with the large worm wheel, which is the inside wheel of the pair in section in Fig. 3. The latter in turn drives a small wheel on a sleeve on the cross-slide screw spindle (Figs. 2 and 3). This sleeve engages, by means of a second spring and dog, the hollow spindle which houses the end of the cross-slide screw, driving the latter by means of a key and slot. For traversing the cross-slide by hand the small hand-wheel is used shown in Fig. 3. In both these movements we have mentioned the use of a spring and dog. The object of introducing these, which give a positive drive with a certain amount of backlash in one direction, is to allow the worms to be slid right into mesh as soon as they engage, so as to transmit the motion to the slides without loss of time. Without this free movement the racking of the worms into mesh would traverse the saddle or slide.

It will be obvious from the construction of the main worm sleeve that only one or the other of the saddle and cross-slide movements can be engaged at a time. The lead screw nut engagement is also interlocked with these two, and can only operate when the worm sleeve is held in neutral and the spring stop is in the central vee-groove at its left-hand end. This will be best understood from Fig. 1, where the upper cross-

5½-IN. TOOL ROOM LATHE.

CONSTRUCTED BY MESSRS. HARRY F. ATKINS, LIMITED, ENGINEERS, PETERBOROUGH.

Fig. 1.

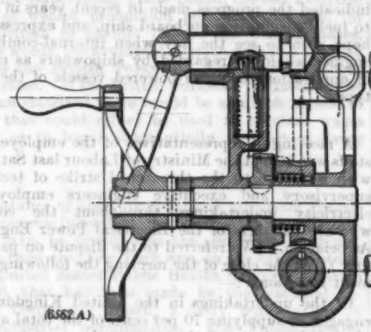


Fig. 2.

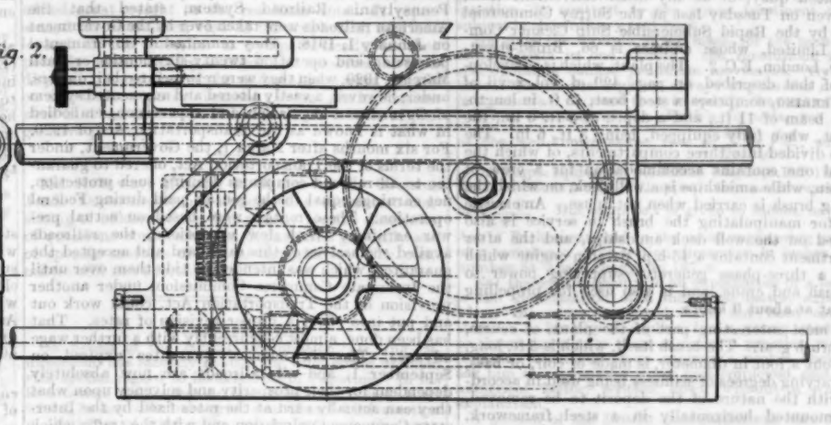
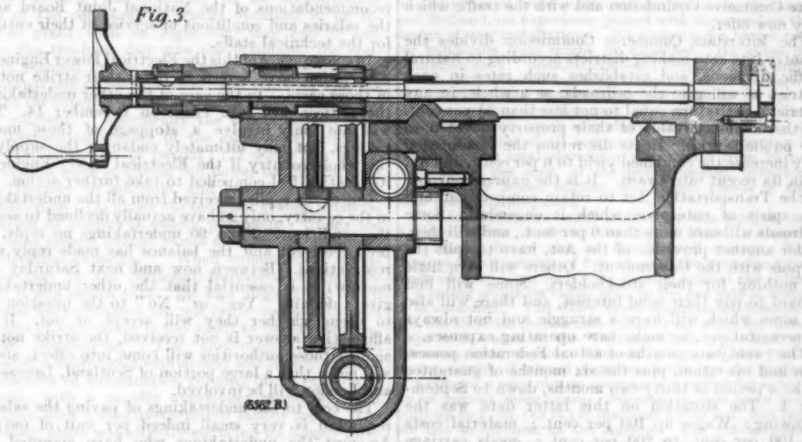


Fig. 3.



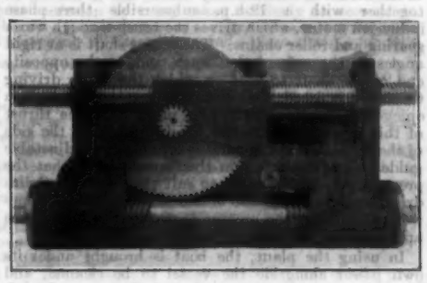


FIG. 4.

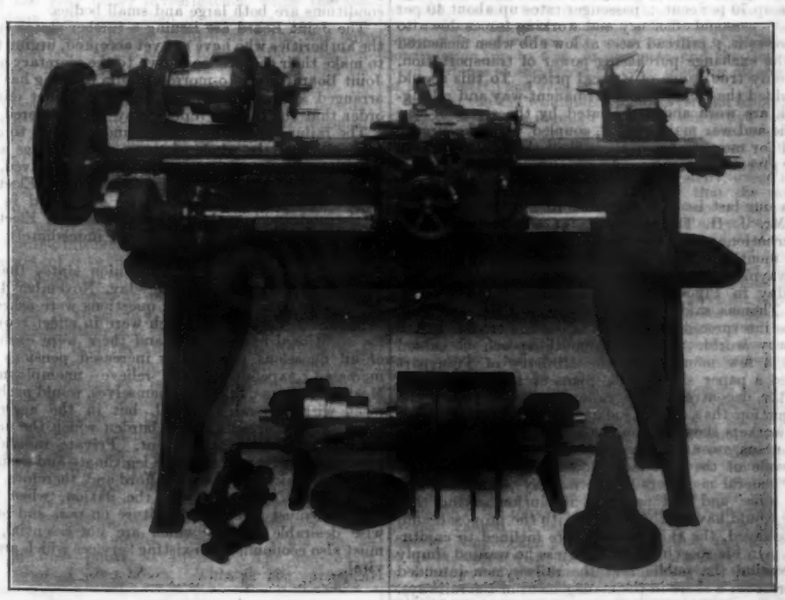


FIG. 5.

hatched portion represents the lead nut in the engaged position. The nut has on its underside a hole, into which, when the nut is withdrawn from the lead screw, the upper end of the spring stop engaging with the worm sleeve (Fig. 2) can rise. In the position shown with the nut engaged, the hole is not vertically over the spring stop or plunger, and the latter being held in neutral no other motion can be engaged. Only when the nut is disengaged can the plunger rise sufficiently to permit of it moving out of its groove on the sleeve so that the latter can be racked to one side or the other. On the other hand, only when the spring stop is in the centre groove is its head low enough to allow the lead screw nut to be worked. By means of the hand-wheels the tool may be run back while either of the power traverses are engaged, but on this being done the power motion automatically cuts out.

The worms are so designed, that together with the spring plunger enough resistance is offered to withstand any reasonable load on the tool, for the capacity of the machine, but should either the cross-slide or the saddle itself come up against a dead stop the spring stop gives way and the worm engaged will wind the sleeve out of action and into the neutral position. This enables the tool to be worked up to shoulders with great accuracy. An adjustable micrometer dead stop is arranged on the bed for use in this connection. The apron is double-walled, and the lower portion under the sleeve acts as an oil-bath from which the oil is carried by the worms and gears to the various working parts. The cross-slide screw is fitted with a hardened collar at its back end which works between hardened plates as shown in Fig. 3. Both screws of the tool-slide are graduated in thousandths of an inch, and micrometer collars are fitted. The top slide is arranged to swivel, and arrangements are made so that the saddle can be fitted with a taper-turning attachment.

THE SOCIETY OF ENGINEERS.—The following are the premium awards for papers read or published by this society during 1920: The president's gold medal to Mr. R. H. Cunningham for his paper on "Some Engineering Work done by the 277th Railway Company (R.E.) in France and Belgium during the War"; the Bessemer premium (5*l.* 5*s.*) to Mr. H. Banks, for his paper on "Blackpool Sea Coast Defence Works"; a Society's premium (3*l.* 3*s.*) to Mr. Alfred S. E. Ackermann, B.Sc. (Eng.) for his paper on "The Physical Properties of Clay"; the Gean premium (open only to members of associated societies), value 5*l.* 5*s.*, to Mr. A. E. A. Edwards, for his paper on "Fuel Economy" (Wolverhampton and District Engineering Society).

PERSONAL.—Sir John Francis Cleverton Snell, Member of Council of the Institution of Civil Engineers and Past-President of the Institution of Electrical Engineers, has been appointed by an Order of Council dated November 23, 1920, to be a member of the Advisory Council to the Committee of the Privy Council for Scientific and Industrial Research.—The Mirrlees Watson Company, Limited, of Glasgow, inform us that they have transferred their London office to The Mirrlees House, 7, Grosvenor Gardens, S.W. 1. Telegrams, "Mirrlees, Sowest, London." Telephone, 9123 Victoria.—The Precision and Thread Grinder Manufacturing Company, manufacturers of the multi-graduated precision Grinder, have moved their offices to 1, South Twenty-first-street, Philadelphia (Pa.).

SHIP-CLEANING PLANT.

A demonstration of their method of cleaning the hull of a ship while it is taking in, or discharging, cargo at a quay, or at any other convenient time, was given on Tuesday last at the Surrey Commercial Docks by the Rapid Submersible Ship Cleaner Company, Limited, whose address is 66, Broad-street-avenue, London, E.C. 2. The plant, which is a development of that described on page 429 of vol. xcvii of Engineering, comprises a steel boat, 45 ft. in length, with a beam of 11 ft., and a depth of 5 ft. 6 in., the draught, when fully equipped, being 3 ft. 6 in. The boat is divided into three compartments, of which the forward one contains accommodation for a crew of four men, while amidships is a well deck, on which the cleaning brush is carried when not in use. An electric crane for manipulating the brush in service is also mounted on the well deck amidships, and the after compartment contains a 45-h.p. paraffin engine which drives a three-phase generator supplying power to the brush and crane, and is also used for propelling the boat at about 9 knots.

The most interesting part of the plant, of course, is the brush gear. The brush itself, which is 5 ft. long, and about a foot in diameter, is made of coir, or bass, fibre, varying degrees of stiffness being used in accordance with the nature of the deposit to be removed. It is mounted horizontally in a steel framework, together with a 12-h.p. submersible three-phase induction motor, which drives the brush through worm gearing and roller chains. The motor shaft is at right angles to the axis of the brush, and, at the opposite end of the shaft to that on which the worm driving the brush is fitted, a bronze propeller, driven through epicyclic reduction gearing, is provided. The thrust of this propeller forces the brush up against the side of the ship when the apparatus is in use, but adjustable guide rollers are fitted on the framework so that the pressure can be regulated to suit the deposit. Cylindrical steel floats are also mounted on the brush framework to support the greater part of the weight of the apparatus in the water.

In using the plant, the boat is brought under its own power alongside the vessel to be cleaned, and secured by ropes passing over winches at each end. Two booms are fixed to the deck of the boat to keep it a suitable distance from the side of the larger vessel and the brush gear is hoisted overboard by means of the crane. Power to the submersible motor is supplied through a cab-tyre sheathed cable which is paid in and out from a drum in unison with the hoisting ropes. On starting the motor the brush is rotated and also pressed against the side of the ship by the action of the propeller, and, being slowly lowered by the crane at the same time, a strip of the vessel's plating, 5 ft. wide, is cleaned down to the level of the bilge keels; a dial indicator, operated from the crane hoisting barrel, shows at a glance the depth to which the brush has descended. The brush is then brought to the surface, still in contact with the side of the ship, and the cleaning vessel is moved a distance of 4 ft. in a fore-and-aft direction by operating the winches; the process is then repeated until the whole length of the ship has been subjected to the treatment.

At the fore and aft ends of the ship the brush can clean the whole of the side of the hull round to the keel, but it cannot, of course, negotiate the bilge keels or clean the horizontal part of the ship's bottom amidships. This part is treated by another process involving the use of a large flat brush which is drawn from side to side under the ship's bottom by means of wire ropes operated by winches. We are informed that, by using suitable brushes, any form of marine growth can be removed by the process above described without damaging the paint, or, if necessary, the hull can be completely scaled and left smooth and clean ready for repainting. If these operations can be satisfactorily done, the time required for painting in dry dock may be much reduced. In the ordinary way the time required to clean a steamer of from 7,000 tons to 8,000 tons is about 8 hours, and the fact that the process can be carried out without in any way affecting the working of the ship will doubtless make a strong appeal to shipowners, who are well aware of the effect of a dirty hull on the coal consumption for a given voyage. It is intended to equip a number of vessels similar to that above described for use at various ports in this country and abroad.

The Society of Motor Manufacturers and Traders.—We understand that this Society has voted a sum of £25,000 for the formation of a fund to be known as the "S.M.M.T. Trust Fund" which will be used for the purpose of granting relief to persons considered eligible as having contributed to the encouragement, promotion, or protection of the motor trade. In addition, the Society has voted a further sum of 5,000*l.* to the Cycle and Motor Trades Benevolent Fund, bringing the total contribution of the Society to that Fund to nearly 14,000*l.*

INDUSTRIAL NOTES.

In the course of an address delivered before the Harrisburg, Pa., Chamber of Commerce, on September 29, Mr. W. W. Atterbury, vice-president of the Pennsylvania Railroad System, stated that the American railroads were taken over by the Government on January 1, 1918. They remained in Governmental possession and operation twenty-six months, or until March 1, 1920, when they were returned to their owners, under, however, a vastly altered and augmented system of Government regulation and supervision, embodied in what is known as the Transportation Act of 1920. For six months after March 1, the Government, under the terms of the Transportation Act, offered to guarantee to all railroad companies desiring such protection, net earnings equal to the rentals paid during Federal operation. These rentals were based on actual pre-war earnings. With few exceptions, the railroads availed themselves of this safeguard and accepted the guarantee, which was intended to tide them over until the Interstate Commerce Commission, under another provision of the Transportation Act, could work out and put into effect a proper revision of rates. That has been done, almost concurrently with a further wage advance. The six months' guarantee expired on September 1, and all railroads are now absolutely dependent for their prosperity and solvency upon what they can actually earn at the rates fixed by the Interstate Commerce Commission and with the traffic which may now offer.

The Interstate Commerce Commission divides the country into rate-making districts according to natural traffic divisions, and establishes such rates in each district as will give the railroads, as a whole, in any district a net return equal to not less than 5½ per cent. on the combined value of their property devoted to the public service. In its discretion the Commission may increase the combined yield to 6 per cent., and did so in its recent rate award. It is the express purpose of the Transportation Act to retain competition and the spirit of enterprise which it engenders. Some railroads will earn more than 6 per cent., and will then, under another provision of the Act, have to split the surplus with the Government. Others will earn little or nothing for their stockholders. Some will find it hard to pay their bond interest, and there will also be some which will have a struggle and not always a successful one, to make bare operating expenses.

The twenty-six months of actual Federation possession and operation, plus the six months of guarantee make a period of thirty-two months, down to September 1. The situation on this latter date was the following: Wages up 100 per cent.; material costs up 100 per cent. to 200 per cent.; goods carriage rates up 70 per cent.; passenger rates up about 40 per cent.; personal efficiency and working forces down to 75 per cent.; railroad rates at low ebb when measured by the exchange purchasing power of transportation, the only true gauge of its real price. To this should be added the fact that the permanent-way and rolling-stock are worn and depreciated by the stress of war traffic and war maintenance, coupled with the urgent need for more transportation than the railroads have ever given.

In our last issue we referred to a statement made by Mr. J. H. Thomas, M.P., at the Railwaymen's International Congress, as to "a big fight in the next few months in this country over a new stand the railwaymen were going to make." Speaking last Sunday in Plymouth to a meeting of railwaymen, Mr. Thomas said he never intended that statement to be interpreted as a threat of coming trouble in the railway world. In his Plymouth speech he added that a few months ago the Ministry of Transport issued a paper showing the plans of the Government for the decontrol of the railways; it contained the suggestion that, in the judgment of the Government, the workers should go on the directorate and share in the management of the railways. He believed this was one of the first steps towards industrial peace. The general managers of the railways, however, had met since and had passed a resolution saying that they would have nothing to do with the proposal, and, he believed, the Government were inclined to capitulate. In his speech at the Congress he wanted simply to remind the public that the railwaymen intended to press for a share in the management of the railways.

On his return, a few days ago, from the United States and Central America, where he visited the mineral oil producing districts, Lord Pirrie is reported to have stated that he has for a long time considered it wrong to burn oil under ship boilers merely for the purpose of raising steam. He felt that only express passenger steamers will be secure for future oil supplies, and he is now advising friends to go slowly in converting ordinary cargo vessels. Every step, he added, should be taken to prevent wasteful use, and this could best be done by the adoption of the internal-combustion engine, provided supplies of Diesel oil were obtainable on the routes on which the vessels traded; to-day, however, it would be a great responsibility for any shipbuilder to advocate the installation of Diesel engines until supplies of the necessary oil are assured.

We may recall that on the occasion of the launch at Barrow, in March last, of the Cunard liner Scythia (Engineering, vol. cix, page 417), Sir James McKechnie indicated the progress made in recent years in regard to fuel consumption on board ship, and expressed the hope soon to see the day when internal-combustion engines would be regarded by shipowners as capable of application to higher-powered vessels of the ocean type.

A meeting of representatives of the employers and staffs was held at the Ministry of Labour last Saturday, with reference to the threatened strike of technical, supervisory and executive engineers employed in electricity undertakings throughout the country, who are members of the Electrical Power Engineers' Association. (We referred to the dispute on page 682 *ante*.) At the close of the meeting the following statement was issued:—

Of the undertakings in the United Kingdom, 101 engaged in supplying 70 per cent. of the total amount of the electricity of the country have accepted the recommendations of the National Joint Board as to the salaries and conditions of service in their entirety for the technical staffs.

In consequence of this the Electrical Power Engineers' Association have agreed to defer their strike notices in those cases. In the case of the other undertakings, the notices will take effect on December 14. This will not only involve a stoppage of these undertakings, but may ultimately endanger the supply to the whole country if the Electrical Power Engineers' Association feel compelled to take further action.

Out of the replies received from all the undertakings in the country, only 28 have actually declined to accept the conditions. From 90 undertakings no reply has been received, and the balance has made reply with reservations. Between now and next Saturday (to-morrow) it is essential that the other undertakings give a definite "Yes" or "No" to the question put to them whether they will accept or not. If an affirmative answer is not received, the strike notices against those authorities will come into effect, and it will mean that a large portion of Scotland, Lancashire and London will be involved.

The cost to the undertakings of paying the salaries requested is very small indeed per unit of output. Amongst the undertakings who have accepted the conditions are both large and small bodies.

The Joint Board are issuing a further statement to the authorities who have not yet accepted, urging them to make their acceptance known to the secretary of the Joint Board before to-morrow, and a meeting has been arranged at the Ministry of Labour on that date in order that the further replies may be considered.

The failure of the rest of the undertakings to come in means that the whole of those undertakings whose acceptance has not been received will be involved.

Should victimisation of members of the Electrical Power Engineers' Association be attempted in any of the undertakings, it will mean that the Electrical Power Engineers' Association will immediately take national action.

The British Commonwealth Union states that on Monday, Tuesday and Wednesday, November 16 to 18 inclusive, no less than 32 questions were asked by Members of Parliament which were in effect requests for additional expenditure, and these were exclusive of all questions relating to increased pensions and increased expenditure to relieve unemployment. Most of the items, taken by themselves, would probably meet with general approval, but in the aggregate they would represent a new burden which the nation cannot afford at the moment. Private individuals have many private wants of a legitimate and desirable character which they cannot afford and, therefore, they forego them. Equally well the nation, when it is hard up, must forego expenditure on new and otherwise desirable objects which are not essential, and must also economise on existing services which are not vital.

The strike of shipyard joiners and carpenters referred to in our last issue is still continuing. It is stated that the employers have no intention of departing from their decision to reduce wages by 12*s.* per week, although they are ready to give sympathetic consideration to the men's proposals for standardisation of wages rates. They contend that, in view of present conditions in the shipbuilding industry, the reduction is necessary and is in the ultimate interests of the men themselves. The latter maintain that as the cost of living has risen since April, when the 12*s.* bonus was granted,

their wages should be increased rather than reduced. In the meantime and in the various districts, the men are being drafted to joinery work in house building and are gradually being absorbed in that trade.

According to a statement made in the daily press by Mr. H. Dubery, general secretary of the Federation of Post Office Supervising Trade Union, the last available figures of wealth production per head give 50*l.* for Great Britain as against 72*l.* for the United States. In other words, the average American does half as much again as the British workman. The hours of labour are the same. If the British workman produced to the American standard there would be available a fund of wealth that could either be used to increase wages further, or to lower substantially the cost of living to all.

An instance of the superficial and unreliable character of economic investigation under the present administration is to be found, says the *American Machinist*, quoting from the *New York Sun*, in the critical study of the United States Public Health Services' Bulletin No. 106, that has been made by the National Industrial Conference Board, a body representing 29 large industrial organisations. The Public Health Service bulletin purported to be an authoritative study of the comparative results obtained in an industrial plant with an eight-hour day and in one where the ten-hour day was the standard, the conclusion reached in the government report being that "a comparison of the eight-hour and ten-hour systems leads to the conclusion that the eight-hour system is the more efficient." Specifically the report states: "(1) The outstanding feature of the eight-hour system is steady maintenance of output; (2) under the eight-hour system work at almost full power begins and ends approximately on schedule, and lost time is reduced to a minimum; (3) under the ten-hour system artificial limitation of output is widely prevalent. Under the eight-hour system output varies more nearly according to individual capacity." When submitted to actual test of fact by the National Industrial Conference Board it was shown that "the two plants from which the data were obtained are not fairly comparable and the basis of experience is too small to justify comprehensive conclusions." The Government Bulletin compared a thoroughly established and highly efficient manufactory of automobiles, running on an eight-hour schedule, with a rapidly expanding munition plant operating with a hastily recruited labour force. The eight-hour plant was slightly reducing its labour force during the year under investigation, while the ten-hour plant had more than doubled its own. The number of women in the eight-hour plant was only about 1 per cent of the entire force, while in the ten-hour plant it was 25 per cent. of the whole; and the operations studied at the eight-hour plant were the characteristic processes of an automobile factory, to which the personnel were thoroughly accustomed, while the operations studied at the ten-hour plant were the novel ones of making brass fuses for shells. The Report of the National Conference Board points out that "the official sanction behind the publication of these conclusions gives them a special prestige in the minds of many people," and adds: "It is always against public interest for unwarranted and unscientific statements of any important problem to be given publicity, whatever the source may be. In these days of industrial unrest it is especially unfortunate if that source is an agency of the Government. Such is the condemnation that can be justly levelled against Public Health Bulletin No. 106." This indictment is all the more effective from the fact that the Conference Board some months ago issued a study of its own on this subject with the statement that the facts reported were not conclusive as to industry. The number of working hours in which economy, efficiency and the welfare of the worker meet to mutual advantage cannot be arrived at from the experience of a single factory or a single industry. Each plant usually must discover for itself. The employees of a Western factory [recently proved to their employers, in a test lasting six months, that they could do as much in nine hours as in ten. The employers gladly lowered the hours. This is the practical and safe way.

A conference of the Joint Industrial Council for the tramways was held last Tuesday to consider the application for an increase in wages of 12*s.* per week for adults and 6*s.* per week for youths under eighteen, to which we referred on page 682 *ante*. Previously to the conference the employers had declined to concede the increase, on the ground that the tramways had reached the limit of their earning capacity. They declined at the conference to accept the men's suggestion to refer the claims to an independent tribunal. Speaking on the matter, Mr. J. Beckett, secretary of the Municipal Tramways Association, said that in almost every case the decision of the Tramways Committee had been ratified by the town councils. This fact added great weight to the resultant vote. It represented the considered view of the employers, who had looked at the question as sympathetically as they possibly could, having in view the resources at their disposal. A number of the undertakings were already on the rates to a material extent; in fact, the indications were that the tramways industry was in a state of progressive poverty.

Mr. Kellaway, Minister in Charge of the Overseas Trade Department, has appointed a committee consisting of officers of the department for the discussion of questions concerning the department generally and of specific matters of special importance. The committee will meet fortnightly.

WIND POWER.

On behalf of the Zionist Organisation, Dr. Ing. M. Mayersohn has recently studied the wind-power problem with special regard to installations in Palestine. In his dissertation, presented to the Berlin Technical High School, he has collected a great deal of useful information on the types of wind mills used in Denmark, Germany and Holland, on experience gained with them and on the design of new installations. He makes out a better case for windmills than might be expected. He gives information on 477 installations—not ordinary grain mills. Of the 415 German mills of those tables 87 per cent. had worked very satisfactorily for periods of up to eighteen years. In Denmark, the utilisation of wind power has been much stimulated during the war; in several instances small communities are co-operating in supplying the local electricity works with from 20 per cent. to 50 per cent. of the power needed, otherwise furnished by Diesel engines, and bigger plants of this kind are being projected.

The favourite new wind motors for this purpose are Agricco motors, made by the firm of Hans L. Larsen, and known hence also as the Hansell motors. The Agricco wheel consists of five wings of the propeller type, made of sheet-iron, each wing turning against the action of a spring about its radial arm, to the one side of which it is attached. The older types common in Denmark are the Paul La Cour wheel—four or six arms set crossways with vanes of the Venetian-blind type—and the Sörensen cone motor. The six wings of this latter motor would, if placed together, make up the surface of a cone of a very obtuse apex angle; each wing is built up of curved cross-vanes. Sörensen motors have been built up to 27 m. (88 ft.) in diameter for 50 h.p., but they are not so efficient as the Agricco. The old-fashioned wind roses, large wheels consisting of many radial vanes of wood, are still built in Denmark; most of the vanes we have mentioned are made of galvanised iron. More common in general are the wind turbines of American construction, up to 5 m. in diameter, and the German wind turbines of the Herkules type, made in diameters of 15 m. (50 ft.) and even 30 m.

Some of the 477 windmills which Mayersohn inspected or about which he inquired had done thirty-five years' duty. La Cour's Askov mill works still after twenty-three years without having ever been repaired. Only six total wrecks were reported. Repairs are not infrequent, especially in some parts of Germany, where the peasants take the notice too literally that the mills require little attendance. Grease was, moreover, very scarce during the war. Trouble had also arisen because the man in charge, finding that the mill could deal with heavy loads, increased the load until the wheel could not turn and became a prey to the wind. In other cases the wheel would not come to rest, causing overflow and other disturbances. Most of the plants serve for pumping, irrigation or drainage; a few mills drive workshops directly, or propel electric machinery with or without accumulator batteries; some of the special dynamos recommended for this purpose have not answered, however.

Small agricultural machinery can generally be fitted for wind power, without difficulty. For installations of more than moderate dimensions, however, the project should be studied as carefully as with water power. A wind velocity of 2 m. per second, which can generally be relied upon in Northern Central Europe, is sufficient to start some types of wheels, though the La Cour wheels, require speeds of 5 m. But the designer has to inquire into the maxima and minima as well as into the average values. A calm of a day or two is a serious feature; longer calm periods during windy days are also to be reckoned with, and in recognition of the utility of wind power the German Meteorological Office has recently supplemented its reports so that the wind velocity can be traced through its diurnal period. Where calm days must be allowed for, the storage capacity of the plant has to be increased. At Haifa, on the coast of Northern Palestine, a good wind is blowing all the summer months, from May to October, but there are calm days in these two months, when the season changes and when irrigation is still necessary. The meteorological observations taken by the German settlers there before the war show that in 1908 there was no wind on May 17 and 18, and again on May 20 and 21, and on May 26 and May 29. To meet this trouble it is recommended that the storage capacity should be increased from two days to at least three days.

"VIBRATION."

TO THE EDITOR OF ENGINEERING.

SIR,—The student of engineering will be grateful to Mr. J. Firth for his practical presentation of the important problem of vibration, as it arises in an engineering question, in contrast to the *jejune* treatment of the subject in the ordinary text book.

He gives the formula in the mass, for the number of double beats in one minute; the revolutions in the corresponding conical pendulum movement. By revolutions (revs.) the engineer always implies the number in 1 minute; no need then to specify the unit of time.

When we analyse Mr. Firth's formula, we arrive at the well-known shape, revs. $= \frac{60}{2\pi}\sqrt{\frac{g}{l}}$, where l is the simple equivalent pendulum length (S.E.P.) in feet; the mysterious factor 54·2 appears then as the equivalent of $\frac{60\sqrt{g}}{2\pi}$. But suppose l is given in inches, as in the Act of Parliament, and in the usual engineering practice of measuring a cross-section dimension in inches; this number 54·2 will change to 187·8.

Not the least difficulty in an explanation of a formula is the identification of a numerical factor, especially where the units employed have not been carefully stated. A healthy discipline for a young student is to throw down on a sheet of paper a practical working formula, taken out of an engineer's pocket book, and ask him to account for every unit employed, and every numerical factor, written down without a word of explanation.

A section of the British Association was once thrown into confusion by being asked suddenly to account in this way for every term in the formula given in Silvanus Thompson's "Electricity and Magnetism," for the capacity of a plate condenser—capacity $= \frac{k\,8}{1{,}130{,}000\,b}$.

For a simple vertical vibration, as of a weight hung on a spring balance, or of a carriage body sinking down to rest on the springs, the S.E.P. l is merely the vertical set or displacement.

But for pendulum oscillation about an axle, as in Mr. Firth's formula, the calculation of l should be divided into two distinct operations, each to be performed separately and checked—

I. The calculation of the moment of inertia (M.I.) of the compound body about the axle, in lb.-ft.^{2}; scalar sum of the M.I. of the separate parts, and calculated by the rules of mensuration.

II. The calculation of the vector sum of the preponderance, in lb.-ft., of the separate parts.

The S.E.P. l, ft., is then the quotient of I by II.

For the rolling or pitching oscillation of a carriage body on its springs, the calculation in II could be replaced by the sum of the moments, in lb.-ft., of the resilience of the springs, divided by $\sin\theta$, for the angular displacement θ from the equilibrium position.

After S.E.P. l has been calculated in this way and a check applied to every step, it will then be safe to substitute l in Mr. Firth's formula.

In many cases the process is inverted, and l is observed to obtain the M.I., say if an artillery projectile. A bifilar pendulum platform for the shell, with the thread of a S.E.P. alongside adjusted to beat time, will enable the M.I. to be inferred about any axis. No need for a time-piece in this the method of Galileo; and a more accurate estimate is obtained by the Method of Coincidences, with the two beats slightly out of time.

The dynamic balance of a large body in rapid rotation has come into prominence with the new steam and water turbine rotor; a slight displacement of a few grains is found of appreciable importance in a large mass weighing tons.

The Vibration Specialist Company, of Philadelphia, advertises a pamphlet on *Vibrating and Rotating Bodies*; and is presumably an expert firm of vibration doctors, prepared to deal with kindred complaints.

Yours faithfully,

G. GREENHILL.

Staple Inn, November 27, 1920.

FUELS FOR AERO ENGINES.—A report recently issued by the United States National Advisory Committee for Aeronautics gives the results of comparative tests of "Alcogas" and petrol as fuels for aero engines. Aviation "Alcogas," prepared by the Industrial Alcohol Company, of Baltimore, Md., for trial by the Navy Department, and by the latter submitted to the Bureau of Standards for test, was apparently a mixture of about 40 per cent. alcohol, 35 per cent. petrol, 17 per cent. benzol, and 8 per cent. other ingredients, but the exact composition and methods of manufacture are trade secrets. The tests made consisted in a direct comparison, in a twelve-cylinder Liberty engine, between "Alcogas" and standard aviation petrol with respect to maximum power attainable, and fuel consumption with the weakest mixture giving maximum power. The tests were made in the altitude laboratory at the Bureau of Standards, where controlled conditions can be made to simulate those of any altitude up to 30,000 ft. The speed range covered was from 1,400 r.p.m. to 1,800 r.p.m., and the altitude range from ground level to 25,000 ft. Two series of comparisons were made, one with a compression ratio of 5·6 and another with a compression ratio of 7·2. From the results obtained it would appear that, in most cases, the maximum power production from "Alcogas" was greater than from petrol, but the consumption of the former fuel was considerably higher. A copy of the above-mentioned report, which is numbered 89, can be obtained on request from the National Advisory Committee for Aeronautics, Washington, D.C., U.S.A.

THE GUY EIGHT-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. GUY MOTORS, LIMITED, ENGINEERS, WOLVERHAMPTON.

(For Description, see opposite Page.)

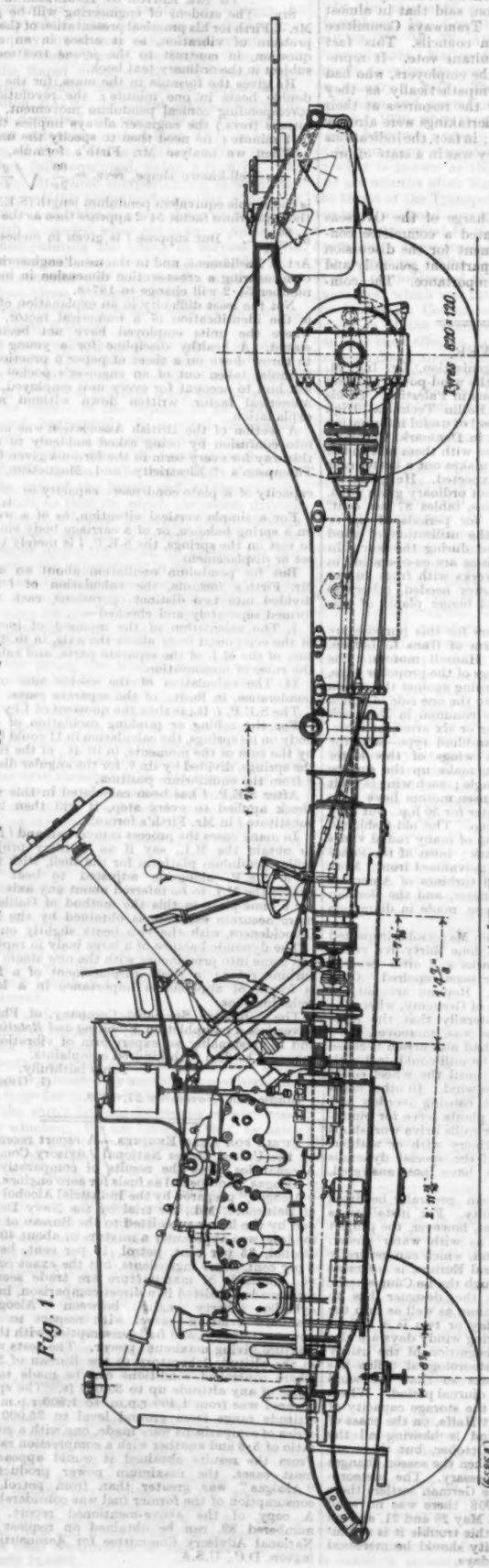


Fig. 1.

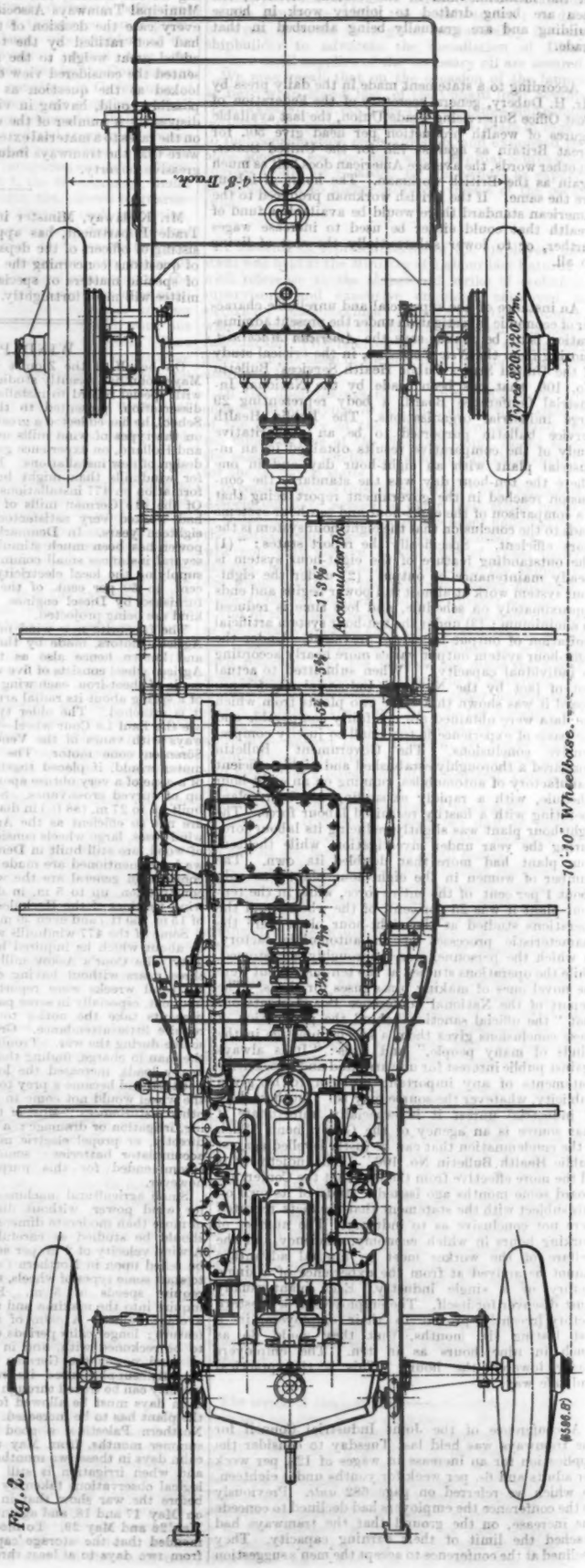


Fig. 2.

ENGINE FOR GUY EIGHT-CYLINDER MOTOR CAR.

CONSTRUCTED BY MESSRS. GUY MOTORS, LIMITED, ENGINEERS, WOLVERHAMPTON.

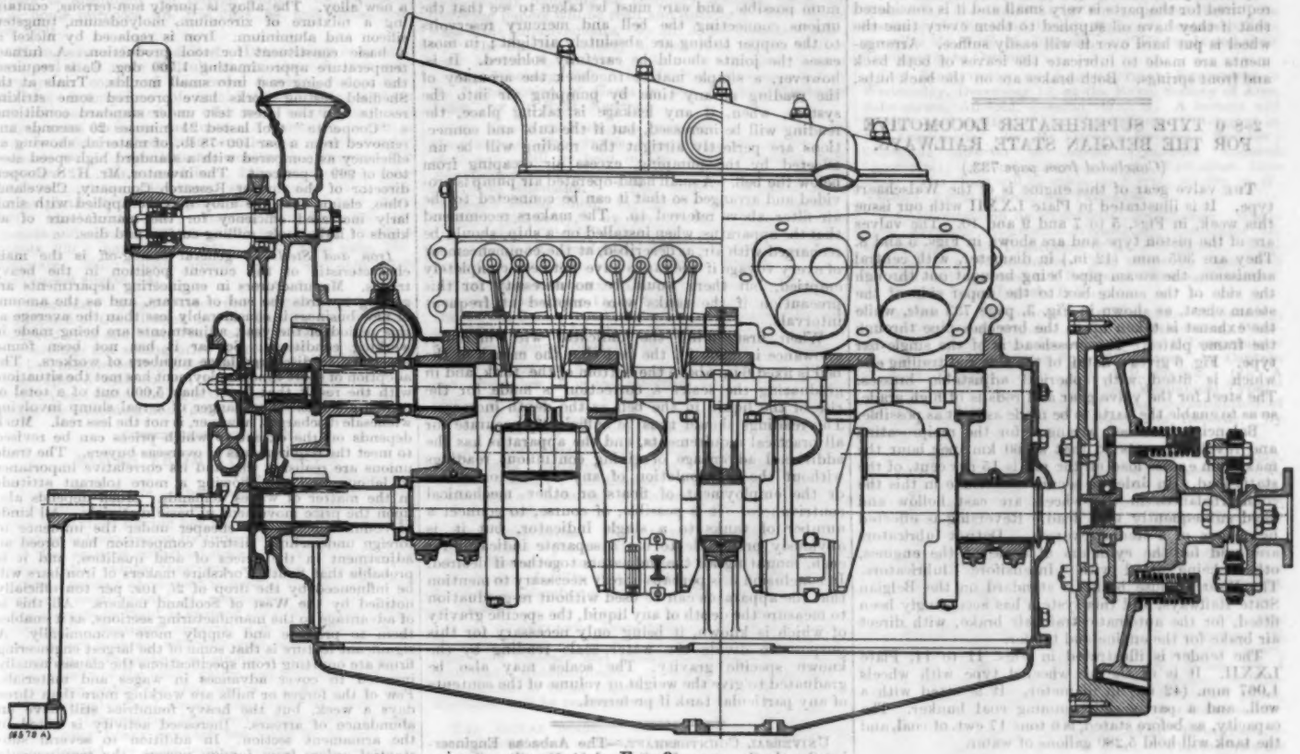


FIG. 3.

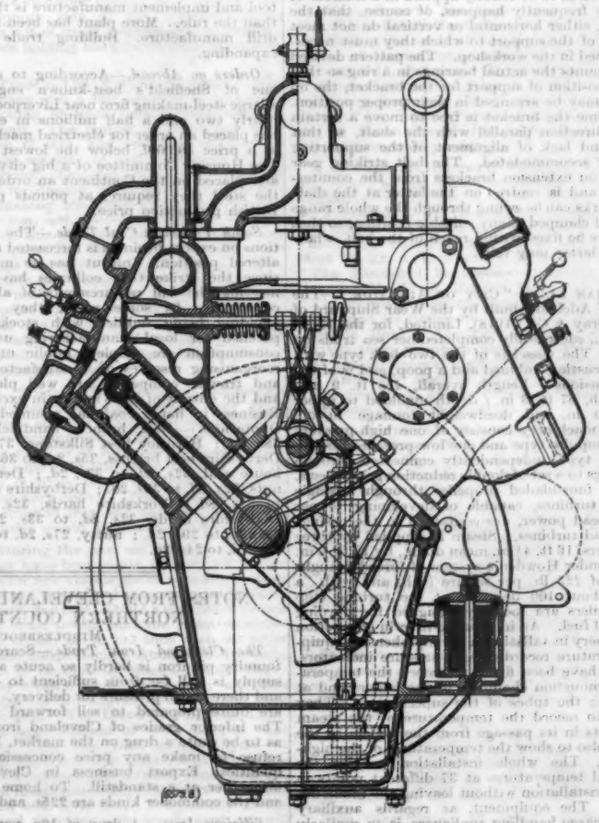


FIG. 4.

EIGHT-CYLINDER cars have not been made in England to any great extent up to date, and therefore a good deal of interest attaches to the Guy car exhibited at the recent Motor Show by Messrs. Guy Motors, Limited, Fallings Park, Wolverhampton. This car is illustrated in Figs. 1 and 2 opposite, whilst Figs. 3 and 4 on this page illustrate its engine.

The cylinders are 72 mm. by 125 mm. (approx. 2¾ in. by 4¼ in.) and are arranged diagonally in the usual way. The valve arrangement is, however, unusual as the valves are placed horizontally and driven by rocking levers from a camshaft placed just over the crankshaft. The whole of the valve gear is open to the crank-case and therefore is well lubricated and is closed in by removable plates through which the valves are easily accessible for adjustment or removal. The arrangement appears to have many advantages over valves arranged parallel with the cylinders, including greater accessibility. It makes possible a better shaped combustion chamber. The exhaust and inlet passages are carried one above and the other below the valves. Each set of four cylinders is cast *en bloc* and has a detachable head. Contrary to usual practice the water joint to this is quite separate from the cylinder head joint, and there is no possibility of water leaking into the cylinders. The crankshaft has three bearings and the cranks have counterbalance weights. Although balance weights are unusual in motor practice they very considerably reduce the pressures on the bearings. Large doors are arranged in the crank-case so that the pistons and connecting rods can be removed from the engine without dismantling it. Lubrication is forced to both main bearings and crank-pins, the oil pump being in the sump and the filter easily accessible for cleaning. Water circulation is by centrifugal pump placed on the end of the camshaft. Ignition is by magneto.

A cone clutch transmits power to a four speed gear-box and the whole engine and gear box are mounted on a subframe which is carried on a three-point suspension. The final drive to back axle is by spiral bevel and both back and front springs are semi-elliptic.

The rake of the steering column can be varied from the driving seat, in fact, if desired, while running. In the body shown the driving seat is adjustable fore and aft and therefore any steering position desired can be obtained. This is a very convenient arrangement.

An unusual feature of the chassis is the lubrication. All the various wearing parts of the chassis such as spring shackles, &c., are lubricated by pipes from the

pressure system of the engine. Where it is necessary to reach moving parts flexible pipes are provided. The oil to this system of piping is controlled by a valve between it and the main system which is opened when the wheel is put fully over into right lock. The amount of oil required for the parts is very small and it is considered that if they have oil supplied to them every time the wheel is put hard over it will easily suffice. Arrangements are made to lubricate the leaves of both back and front springs. Both brakes are on the back hubs.

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAYS.

(*Concluded from page* 733.)

The valve gear of this engine is of the Walschaert type. It is illustrated in Plate LXXII with our issue this week, in Figs. 5 to 7 and 9 and 10. The valves are of the piston type and are shown in Figs. 5 and 8. They are 305 mm. (12 in.) in diameter, with central admission, the steam pipe being brought out through the side of the smoke-box to the upper side of the steam chest, as shown in Fig. 3, page 733 *ante*, while the exhaust is taken up to the breeches pipe through the frame plates. The crosshead is of the single-bar type. Fig. 6 gives a detail of the side rod trailing end which is fitted with spherical adjustable brasses. The steel for the valve gear and rods is of high grade, so as to enable the parts to be made as light as possible.

Balancing has been arranged for the reciprocating and revolving parts so that at 60 km. per hour the maximum excess load on the rail is 15 per cent. of the static load. In order to secure exactitude in this the counterbalances in the wheels are cast hollow and filled subsequently with lead. Reversing is effected by means of a steam reverser. Detroit lubricators are used for the cylinders of some of the engines, others being fitted with "Intensifore" lubricators. The Westinghouse brake is standard on the Belgian State Railways, and this system has accordingly been fitted, for the automatic train air brake, with direct air brake for the engine and tender.

The tender is illustrated in Figs. 11 to 14, Plate LXXII. It is of the six-wheeled type with wheels 1,067 mm. (42 in.) in diameter. It is fitted with a well, and a partly self-trimming coal bunker. The capacity, as before stated, is 6 tons 17 cwt. of coal, and the tank will hold 5,280 gallons of water.

DEPTH INDICATOR FOR LIQUIDS IN TANKS.

Our attention has been called to a new design of indicator for showing the depth of liquids in tanks, known as the "Teledep" tank indicator, and made by Messrs. Dobbie McInnes and Clyde, Limited, 57, Bothwell-street, Glasgow. The instrument, suitably graduated, can be used with liquids of any specific gravity in open tanks or in closed vessels under pressure or vacuum, or it may be employed to show the depth of water in docks and reservoirs, the height of the tides, or for any other work of a similar nature which may suggest itself. One important application, for which a number of these instruments have already been installed, is for indicating the depth of water or oil fuel in ships' tanks, for which purpose they have the advantage, among others, that the indicator can be placed at any distance from the tank or at any level above or below it.

The instrument comprises two main parts—an air bell fixed in the tank with its open end 6 in. from the bottom and a mercury column indicator fixed in any convenient position. The bell is connected, by solid-drawn copper tubing of ¼ in. bore, to the top of a mercury reservoir, which forms part of the indicator, and as the air pressure in the bell varies in accordance with the depth of liquid in the tank, the mercury from the reservoir is forced up a glass tube to a height sufficient to balance the pressure at all times. Adjacent the glass tube are two scales, graduated so that the level of the mercury meniscus shows, in one case, the corresponding depth of water in the tank, and, in the other case, the depth of oil or any other liquid of which the specific gravity has been previously specified. The upper end of the glass tube is connected to a short loop of copper tubing, the other end of which is open to the atmosphere through an air filter. The object of the latter is to prevent dust and dirt from being drawn into the tube with the air displaced by the movement of the mercury column. When used with a closed tank under pressure or vacuum, this tube would, of course, have to be connected to the tank at some point above the highest possible level of the liquid.

A moment's consideration will show that the reading of the indicator is practically unaffected by the temperature of the latter or of the tubing connected to the bell, depending only on the pressure due to the head of liquid over the bell. It is thus possible to run the tubing through the boiler rooms or refrigerating chambers of a ship without insulation. Any leakage of the air enclosed in the system would, however, seriously affect the readings by allowing the liquid to rise in the bell and connecting tube. To avoid this the number of joints in the tubing is reduced to the minimum possible, and care must be taken to see that the unions connecting the bell and mercury reservoirs to the copper tubing are absolutely airtight; in most cases the joints should be carefully soldered. It is, however, a simple matter to check the accuracy of the reading at any time by pumping air into the system, when, if any leakage is taking place, the reading will be increased, but if the tube and connections are perfectly airtight the reading will be unaffected by the pumping, excess air escaping from below the bell. A small hand-operated air pump is provided and arranged so that it can be connected to the air filter above referred to. The makers recommend that the apparatus, when installed on a ship, should be recharged with air, as described, at the commencement of every voyage if the tanks have not been completely emptied, but there would be no necessity for this precaution if the tanks were emptied at frequent intervals.

When first filling the indicator with mercury, allowance is made for the fact that the mouth of the bell is fixed 6 in. above the bottom of the tank, and in graduating the scales a correction is made for the rise of the liquid in the bell as the depth increases. The readings should thus be sufficiently accurate for all practical requirements, and the apparatus has the additional advantage of giving continuous readings without the manipulation of any valves or cocks, or the employment of floats or other mechanical contrivances. It is possible, of course, to connect a number of tanks to a single indicator, but it is obviously preferable to use a separate indicator for each, mounting all the indicators together if desired. In conclusion it is perhaps hardly necessary to mention that the apparatus can be used without re-graduation to measure the depth of any liquid, the specific gravity of which is known, it being only necessary for this purpose to divide the water scale reading by the known specific gravity. The scales may also be graduated to give the weight or volume of the contents of any particular tank if preferred.

Universal Countershaft.—The Anbacas Engineering Supply Company, Limited, of 44, Hamilton Square, Birkenhead, have recently introduced a form of countershaft designed so as to be readily applied in a number of ways. It very frequently happens, of course, that the usual brackets, either horizontal or vertical do not meet the conditions of the support to which they must necessarily be attached in the workshop. The pattern devised by this firm mounts the actual bearings in a ring so that whatever the position of support for the bracket, the oil reservoir, &c., may be arranged in their proper position. At the same time the bracket is free to move a certain amount in a direction parallel with the shaft, so that irregularities and lack of alignment of the supporting surface can be accommodated. The belt striking gear is also carried on extension brackets from the countershaft-brackets, and is centred on the latter at the shaft centre. The forks can be swung through the whole range of 360 deg., and clamped at any suitable position, so that they can always be fixed within reach of the belt, whatever angle the latter may take.

The Ellerman Liner "City of Adelaide."—The steamer City of Adelaide, built by the Wear Shipyard of Messrs. Wm. Gray & Co. (1918), Limited, for the Ellerman Lines, Ltd., successfully completed her sea trials on the 2nd inst. The vessel is of the two-deck type with bridge and forecastle combined and a poop, and is of the following dimensions:—Length overall, 450 ft. 9 in.; extreme breadth, 57 ft. 3 in.; depth moulded to upper deck, 32 ft. 10 in. and deadweight tonnage 10,600. The propelling machinery consists of one high-pressure turbine of the impulse type and one low-pressure turbine of the reaction type, independently connected through flexible couplings to a set of double reduction gear wheels, which drive a four-bladed propeller through a single shaft. Astern turbines, capable of developing 70 per cent. of the ahead power, are contained in the casings of the two ahead turbines. Steam is supplied by three cylindrical boilers, 16 ft. 4½ in. mean diam., by 12 ft. 6 in. long, working under Howden's system of forced draught at a pressure of 225 lb. per square inch, and with a superheat of about 100 deg. F., at the turbine stop valve. The boilers are specially designed for burning either coal or oil fuel. An interesting item in connection with the machinery installation is a comprehensive equipment of temperature recorders and pressure indicators. Thermocouples have been fitted to record the temperatures in the combustion chambers of the boilers and at every foot along the tubes of the superheaters. They are also used to record the temperature of the steam at various points in its passage from the boilers to the condenser and also to show the temperatures of the high-speed bearings. The whole installation enables the engineer to read temperatures at 37 different points in the machinery installation without leaving the manœuvring platform. The equipment, as regards auxiliary machinery and cargo handling appliances, is on similarly up-to-date lines, so that the performance of the vessel in practice will be watched with considerable interest.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

A New Alloy.—Considerable interest has been aroused in engineering quarters respecting the remarkable efficiency in machine tool form claimed for "Cooperite," a new alloy. The alloy is purely non-ferrous, containing a mixture of zirconium, molybdenum, tungsten, silicon and aluminium. Iron is replaced by nickel as a basic constituent for tool production. A furnace temperature approximating 1,700 deg. C. is required, the tools being cast into small moulds. Trials at the Sheffield testing works have procured some striking results. In the latest test under standard conditions, a "Cooperite" tool lasted 21 minutes 20 seconds and removed from a bar 100·78 lb. of material, showing an efficiency as compared with a standard high-speed steel tool of 969·5 per cent. The inventor, Mr. H. S. Cooper, director of the Cooper Research Company, Cleveland, Ohio, claims that the alloy may be applied with similarly increased efficiency for the manufacture of all kinds of lathe tools, milling cutters and dies.

Iron and Steel.—A general easing-off is the main characteristic of the current position in the heavy trades. Manufacturers in engineering departments are getting towards the end of arrears, and as the amount of new business is considerably less than the average at this period of the year, adjustments are being made in working conditions. So far it has not been found necessary to discharge large numbers of workers. The adoption of short time employment has met the situation, with the result that fewer than 5,000 out of a total of 80,000 are idle. The danger of a real slump involving wholesale discharges, however, is not the less real. Much depends on the extent to which prices can be revised to meet the requirements of overseas buyers. The trade unions are realising this and its correlative importance to labour, and are showing a more tolerant attitude in the matter of wages demands. Much depends also upon the price movement in basic materials. All kinds of common steels are cheaper under the influence of foreign undercelling, district competition has forced an adjustment in the prices of acid qualities, and it is probable that South Yorkshire makers of iron bars will be influenced by the drop of 2*l.* 10*s.* per ton officially notified by the West of Scotland makers. All this is of advantage to the manufacturing sections, as it enables them to produce and supply more economically. A significant feature is that some of the largest engineering firms are omitting from specifications the clauses usually inserted to cover advances in wages and materials. Few of the forges or mills are working more than three days a week, but the heavy foundries still have an abundance of arrears. Increased activity is noted in the armament section. In addition to several substantial orders from foreign powers, the requirements of the British Admiralty are now anticipated to be on a larger scale than was originally expected. Slackness in tool and implement manufacture is the exception rather than the rule. More plant has been laid down for twist drill manufacture. Building trade requirements are expanding.

Orders go Abroad.—According to a representative of one of Sheffield's best-known engineering concerns, a large steel-making firm near Liverpool which is spending nearly two and a half millions in extensions to plant has placed an order for electrical machinery in Germany, at a price 50,000*l.* below the lowest British quotation. The Housing Committee of a big city near Sheffield has also placed on the Continent an order for the whole of the steel they require, at pounds per ton below the British production price.

South Yorkshire Coal Trade.—The removal of restrictions on export business is forecasted as the result of the altered position. Output has so materially increased since the strike that collieries have no difficulty in meeting the full requirements of all classes of home consumers. In some cases, they find difficulty in avoiding being saddled with stocks. Tonnages despatched for local manufacturing use and for inland consumption are ample; public utility concerns are reorganising reserves on a satisfactory basis; railway and trawler companies are well placed for supplies; and the output of coke is now in excess of the demand. Business in house coal has resumed a normal aspect. Quotations:—Best branch handpicked, 37*s.* 2*d.* to 38*s.* 2*d.*; Barnsley best Silkstone, 37*s.* 2*d.* to 37*s.* 8*d.*; Derbyshire best brights, 35*s.* 2*d.* to 36*s.* 2*d.*; Derbyshire house coal, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire best large nuts, 32*s.* 8*d.* to 33*s.* 2*d.*; Derbyshire small nuts, 31*s.* 8*d.* to 32*s.* 8*d.*; Yorkshire hards, 32*s.* 8*d.* to 33*s.* 8*d.*; Derbyshire hards, 32*s.* 8*d.* to 33*s.* 2*d.*; rough slacks, 28*s.* 2*d.* to 29*s.* 2*d.*; nutty, 27*s.* 2*d.* to 28*s.* 2*d.*; smalls, 23*s.* 2*d.* to 24*s.* 2*d.*

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

Middlesbrough, Wednesday.

The Cleveland Iron Trade.—Scarcity of Cleveland foundry pig-iron is hardly so acute as it has been, but supply is still far from sufficient to cover early needs, and there is still pressure for delivery. Makers, however, are quite prepared to sell forward at present prices. The inferior grades of Cleveland iron are so plentiful as to be quite a drug on the market, but producers still refuse to make any price concessions for the lower qualities. Export business in Cleveland pig-iron is altogether at a standstill. To home customers, No. 3 and the commoner kinds are 225*s.* and No. 1 is 237*s.* 6*d.*

Silicious Iron.—A drop of 10*s.* per ton in the home quotation for silicious iron, making the figure 245*s.*, has caused no surprise. Lately there has been rather

more of this class of iron on the market, and the price was high as compared with other pig-iron quotations.

Hematite Iron.—East Coast hematite, whilst by no means plentiful, is less difficult to purchase for early delivery, and sellers are pressing forward business. A distinctly easier tendency is noticeable in this branch. There is absolutely no foreign inquiry for hematite. For home purposes No. 1 is 262*s.* 6*d.* and mixed Nos. are 260*s.*

Manufactured Iron and Steel.—Transactions in finished iron and steel were difficult to put through, due very largely to continued successful foreign competition. Various descriptions of semi-finished material from abroad were reported on offer here at pounds below ruling rates for home products. A reduction of 50*s.* in iron bars leaves them still considerably above Belgian prices. Other quotations are unaltered. Common iron bars are 27*l.* 10*s.*; steel bars, 24*l.*; steel ship, bridge and tank plates, 24*l.* 10*s.*; steel angles, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; steel boiler plates, 31*l.*; steel joists, 24*l.*; channels and flats, 24*l.* 5*s.*; rounds and squares, 26*l.* 10*s.*; soft billets, 23*l.*; medium billets, 23*l.*; hard billets, 24*l.*; heavy steel rails, 25*l.*; fishplates, 30*l.*; black sheets, 30*l.*; and corrugated galvanised sheets, 34*l.*

Ironworkers' Wages.—According to the accountant to the Board of Conciliation and Arbitration for the Manufactured Iron and Steel Trade of the North of England, the average net selling price of iron bars and angles for the two months ending October 31 last was 30*l.* 0*s.* 8·21*d.*, as compared with 30*l.* 0*s.* 10·94*d.* for the previous two months, and under sliding scale arrangements ironworkers wages for December and January are unaltered.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—There has been no improvement in the steel trade of Scotland during the past week and very little fresh buying has taken place. The recent fall in prices is looked upon by buyers as only the forerunner, and that another reduction may come along in the near future, after which they will consider ordering. The business passing at present is mainly to cover the most pressing requirements of consumers, but that, with the contracts on hand, is keeping the rolling mills running fairly well. Sectional material is in very poor demand. Black sheet makers, although very few new orders are coming in, have quite a satisfactory amount of work on hand, chiefly of the heavy gauge, but find some difficulty in securing orders for thin sheets. There is not much outlet for galvanised sheets, and prices are inclined to be easier. Competition from the Continent is developing, but no very heavy tonnage has come in so far. The prices quoted are considerably under those named by local firms, but quality and delivery are the important factors, and no matter how cheap the price the offer is useless unless the required quality and delivery are assured. The shipping side of the industry shows little change and is not of great consequence at present, as foreign buyers are holding back for further reductions in prices.

Malleable Iron Trade.—The West of Scotland malleable iron makers have still a fair amount of orders on hand, but the booking of fresh business has recently been extremely small. The matter of prices has been under consideration of late, and owing to the foreign competition and the scarcity of new orders quotations have now been reduced. This was arranged at a meeting of the makers held in Glasgow on Monday, and amounts to 50*s.* per ton, making the basis price of "crown" bars 27*l.* 10*s.* per ton, net, delivered Glasgow station. In the early days of this year the price was 5*l.* per ton less than the new quotation, but owing to rising costs and heavy bookings the price rose steadily until 30*l.* per ton was touched in the month of May, since when no change was made until this week. It is anticipated that the reduced price will induce consumers to fix up new contracts, but the latter are chary of a falling market and may "wait and see" if to-day's price will not be further shaded in the near future before placing more than their immediate needs.

Scotch Pig-Iron Trade.—The prevailing conditions in the Scotch pig-iron trade have varied very little during the past week and the scarcity of both foundry and hematite iron is very marked. The output at present, owing to the fewer number of furnaces in blast, is just barely sufficient to cope with the home demand, and in consequence there is little being exported. Inquiries from abroad are not very heavy. Prices are easier, and this may tend to finished iron and steel becoming still lower in price, which would facilitate business.

Shipbuilding.—During the past six months, or thereabouts, intimations have been made periodically of the cancelling of orders for new vessels placed with shipbuilders which owners could not now afford to run at a profit in relation to their present-day cost. Quite a number of vessels were deleted from order books, and the latest cancellations include four vessels of 10,600 tons each on order for the Lloyd Royal Belge Société Anonyme, Antwerp, two of which were to be built by Messrs. Denny, Dumbarton, and two by Messrs. Scott, Greenock; and also two vessels on order for Norwegian owners which were to be built at Greenock. The Lloyd Royal Belge Company, had quite a large amount of work mapped out for construction at their own yard on the Clyde—at Whiteinch—during the next few years, but prevailing conditions have now altered the owners' ideas and the programme is to be much restricted. It is even probable that their shipyard will close down temporarily at the end of the year and that the only hands kept on will be the staff and apprentices.

NOTICES OF MEETINGS.

THE PHYSICAL SOCIETY OF LONDON.—Friday, December 10, at 5 p.m., at the Imperial College of Science, South Kensington, S.W., a Special General Meeting to consider alterations in the Articles of Association. Immediately following an Ordinary Meeting, when the following papers will be read and discussed: (1) "Some Slide Rule Improvements," by Mr. J. St. Vincent Pletts; (2) "The Current Density in the Crater of the Carbon Arc," by Mr. N. A. Allen, B.Sc.; (3) "Sodium Vapour Electric Discharge Tube," by Mr. F. H. Newman, M.Sc.; (4) "Absorption of Gases in the Electric Discharge Tube," by Mr. F. H. Newman.

THE NORTH OF ENGLAND INSTITUTE OF MINING AND MECHANICAL ENGINEERS.—Saturday, December 11, at 2 p.m., will be held in the Wood Memorial Hall, Newcastle-upon-Tyne. The following papers will be open for discussion: "The Electric Welding of a Corroded Boiler Shell," by Mr. A. Kenneth Dawson; "Steam Economy," by Mr. Philip Kirkup, Junior, D.S.O., M.C. The following paper will be read or taken as read: "The Production and Tranamission of Compressed Air in Mines," by Mr. John T. Pringle.

THE STAFFORDSHIRE IRON AND STEEL INSTITUTE.—Saturday, December 11, at 6.30 p.m., at the Education Offices, St. James'-road, Dudley, a meeting will be held at which a paper by Mr. C. E. Roberts, B.Sc., will be read, on "Some Blast-Furnace Problems of To-day."

THE KEIGHLEY ASSOCIATION OF ENGINEERS.—Saturday, December 11, in the Assembly Room of the Cycling Club. Lecture by Mr. C. H. Ebbrell, of Leeds. Subject, "Electric Welding." Chair to be taken at 6.30 p.m. by the President, Mr. John Whitehead, F.C.I.P.A.

THE INSTITUTION OF MECHANICAL ENGINEERS: GRADUATES SECTION.—Monday, December 13, at 7 p.m. Paper: "Die Casting," by Mr. A. G. Hopking, Graduate, of London. Chairman, Mr. L. A. Legros, O.B.E., Member.

THE SURVEYORS' INSTITUTION.—Monday, December 13, when a paper will be read entitled: "The Work of the Measuring and Quantity Surveyor, and the Use and Abuse of Bills of Quantities," by Mr. F. H. A. Hardcastle, Member of Council. The chair will be taken at 8 p.m.

THE CLEVELAND INSTITUTION OF ENGINEERS.—Monday, December 13, at 6.30 p.m., in the Hall of the Cleveland Literary and Philosophical Society, Corporation-road, Middlesbrough. A paper on "Welding of Blow-holes in Steel Ingots," by Mr. Harry Brearley, Sheffield, will be read and discussed.

THE ROYAL SOCIETY OF ARTS.—Monday, December 13, at 8 p.m.: Cantor Lecture, "Micro-Organisms and Some of their Industrial Uses," by Mr. A. Chaston Chapman, F.R.S., F.I.C. (Lecture II). Wednesday, December 15, at 8 p.m.: Ordinary Meeting, "Forestry," by Major-General The Right Hon. Lord Lovat, K.T., K.C.M.G., K.C.V.O., C.B., D.S.O.; The Right Hon. the Earl of Selborne, K.G., G.C.M.G., President of the Board of Agriculture, 1915–10, will preside. Friday, December 17, at 8 p.m.: Extra Meeting, "The Breeding of Sheep, Llamas and Alpacas in Peru, with a view to supplying improved Raw Material for the Textile Trades," by Colonel Robert J. Stordy, C.B.E., D.S.O.; Mr. G. Acton Davis, J.P., chairman of the Peruvian Corporation, will preside.

THE FARADAY SOCIETY.—Monday, December 13, at 8.15 p.m., at the Chemical Society, Burlington House, Piccadilly, W. 1. Dr. A. E. Oxley will present a paper by Professor E. D. Campbell (University of Michigan) and open a discussion on "A Force Field Dissociation Theory of Solution Applied to some Properties of Steel"; Mr. A. L. Norbury, M.Sc., will read a paper on "The Electrical Resistivity of Dilute Metallic Solutions"; Mr. W. E. Hughes, B.A., will read a paper on "The Forms of Electro-deposited Iron and the Effect of Acid upon its Structure. Part I. Deposited from the Chloride Bath." Contributions to the discussion are invited from members unable to attend the meeting. The Annual General Meeting will be held at 8 p.m., before the Ordinary Meeting. The Report of the Council, to be presented at the meeting, was published in the July issue of the Proceedings.

THE BRADFORD ENGINEERING SOCIETY.—Monday, December 13, at 7.30 p.m., in the Hall of the Bradford Technical College. Mr. H. L. Armstrong (London), on "Recent Developments in the Low-Temperature Carbonisation of Coal."

THE INSTITUTE OF TRANSPORT.—Monday, December 13, at 5.30 p.m., at the Institution of Civil Engineers, Great George-street, Westminster, when a paper entitled "The Future of Road Transport," will be read by the Right Hon. Lord Montagu of Beaulieu, K.C.I.E., C.S.I., Member. The chair will be taken by the Hon. Sir Arthur Stanley, G.B.E., C.B., M.V.O.

THE ILLUMINATING ENGINEERING SOCIETY.—Tuesday, December 14, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, when the hon. secretary will present a Report on Progress during the Vacation, and there will be some exhibits illustrating new developments in lamps and lighting appliances, illumination-photometers, &c.

THE INSTITUTION OF ELECTRICAL ENGINEERS: SCOTTISH CENTRE.—Tuesday, December 14, at 7.30 p.m., in the Rooms, 207, Bath-street, Glasgow, when Mr. W. B. Woodhouse will read his paper on "The Distribution of Electricity."

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, December 14, at 5.30 p.m. Paper to be read: "Notes on the Standardisation of Shock Tests," by Sir Robert Abbott Hadfield, Bart., D.Sc., F.R.S., M.Inst.C.E., and Mr. S. A. Main, B.Sc.; and discussion on this Paper and on the three papers on Notched-Bar Tests read at the meeting on November 30; also ballot for new members.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—Wednesday, December 15, at 7 p.m., at the Hall of the Institute of Chartered Patent Agents, a lecture will be given by Mr. G. E. M. Johnson, on "Decimals and their Application to Costing."

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Wednesday, December 15, at the Royal Society of Arts, John-street, Adelphi, London, W.C. 2. A lecture will be delivered entitled "The Possibilities of Aviation in the Dominions," by Mr. Hector Sleeman, Member; managing director of Aerial Transport, Limited (Australia); general secretary of the Australian Aero Club. The chair will be taken at 5 p.m., by Mr. A. H. Ashbolt, Agent-General for Tasmania.

THE INSTITUTION OF ELECTRICAL ENGINEERS: WIRELESS SECTION MEETING.—Wednesday, December 15, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. The following paper will be read and discussed: "Range of Wireless Stations," by Captain R. C. Trench, R.E.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, December 15, at 5 p.m., at 70, Victoria-street, Westminster. Papers to be read: (1) "Temperature Variations in the Lowest Four Kilometres," by Captain C. K. M. Douglas, A.F.C., B.A., F.R.Met.Soc.; (2) A New Form of Sunshine Recorder (Mechanical Type)," by Mr. A. P. Wainwright; (3) "An Investigation of River Flow, Rainfall and Evaporation Records," by Lieutenant-Colonel J. E. E. Craster, O.B.E.

THE ROYAL AERONAUTICAL SOCIETY.—Thursday, December 16, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, papers will be read by Mr. H. Ricardo, on "Possible Developments in Aircraft Engines," and Mr. A. J. Rowledge, on "The Installation of Aeroplane Engines."

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, December 16, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. Discussion of Report on the Heating of Buried Cables.

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Thursday, December 16, at 2.30 p.m., at the University, St. George's-square, Sheffield. Paper: An abstract on the "Memo. No. 1 of the Miners' Lamp Committee," will be read by Professor F. E. Armstrong. Dr. R. V. Wheeler's paper, "Firedamp Explosions," will be open for discussion.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, December 17, at 6 p.m., "Thermodynamic Cycles in Relation to the Design and Future Development of Internal-Combustion Motors," by Mr. William J. Walker, Ph.D., of Manchester, Associate Member.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—A proposal of an important and far-reaching character was considered by the South Wales Coalowners' Association yesterday. It was that minimum f.o.b. prices be fixed for the sale of export coal on the basis of 82*s.* 6*d.* for best Welsh steam large and 60*s.* for No. 1 steam smalls. The prices suggested were, in the case of large 10*s.* above the prices at which the French Bureau des Charbons is ready to sanction contracts for 1921 delivery, and in respect to smalls 15*s.* higher. In view of the fact that a deputation of French importers is coming to London shortly to confer with coalowners it was decided to leave the question of minimum prices over. There was, however, a strong feeling against the adoption of minimum prices, principally on the grounds that the law of supply and demand should be allowed to take its course, and that the establishment of an effective minimum scale would probably lead to restriction in outputs. It will be recalled that in the recent terms of settlement of the miners' strike it was agreed that the colliery owners and workmen should set up committees with the object of securing an increase in production. At a meeting of the South Wales Coal Board yesterday the owners intimated their readiness to set up such a committee, but the workmen's representatives stated that they were not in a position to give the necessary particulars at the present time as full consideration had not yet been given to the proposal. The coalowners some time ago issued a uniform contract form for the sale of export coal. Lately various foreign importers have endeavoured to obtain guarantees with regard to percentage of ash, volatile matter, &c., contained in coal sold under contract. Previous to the war it was the custom of many exporters to give such guarantees, but not so the coal-owners. The coalowners have now decided to add a new clause to the contract form that coal shall not be resold under any specific guarantee as to quality, also that purchasers agree to pay to the vendors as liquidated damages 3*s.* per ton for every ton sold in violation of this clause. The market position is unchanged. Dock facilities are unable to cope with arrivals of coal at the docks in a prompt manner, and there is a congestion of shipping. The inquiry, too, from abroad is restricted, and importers generally are holding off and refusing to pay current values. Despite this there is no break in the price of best quality coals, which are round 112*s.* 6*d.* for best steam large and 92*s.* 6*d.* for best smalls. Inferior grades, however, are freely offered and difficult to dispose of. Throughs are especially weak at 85*s.* for best steams and 75*s.* for bituminous sorts.

COAL-CUTTING AND CONVEYING PLANT AT THE GLASGOW EXHIBITION.

CONSTRUCTED BY MESSRS. MAVOR AND COULSON, LIMITED, ENGINEERS, GLASGOW.

(*For Description, see Page* 761.)

FIG. 57. BAR-TYPE COAL-CUTTER.

FIG. 58. CHAIN-TYPE COAL-CUTTER.

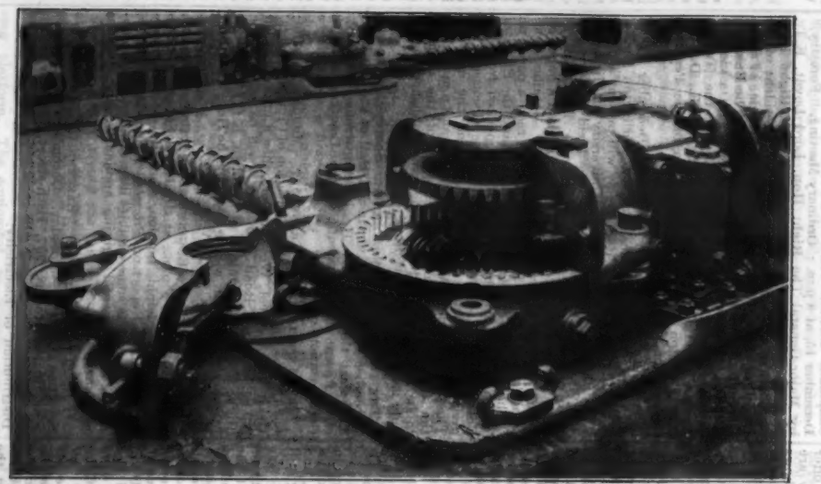


FIG. 59. DRIVING MECHANISM OF BAR-CUTTER.

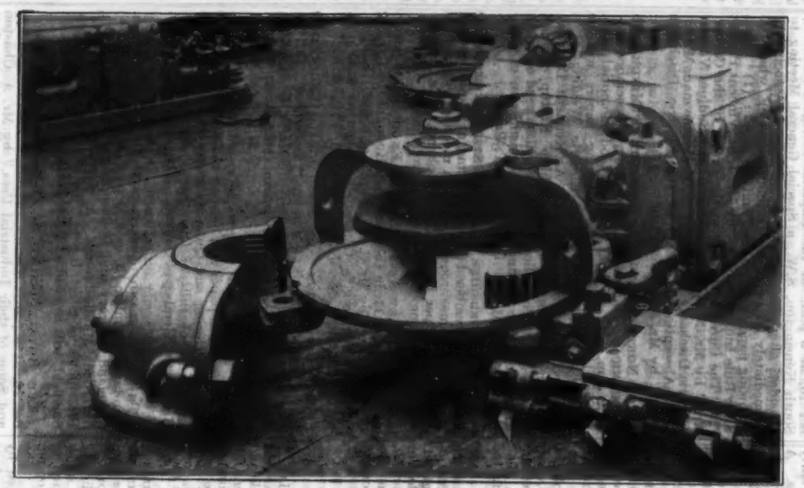


FIG. 60. DRIVING MECHANISM OF CHAIN-CUTTER.

FIG. 61. DRIVING GEAR FOR SHAKER CONVEYOR.

FIG. 62. DRIVING GEAR FOR BAND CONVEYOR.

2-8-0 TYPE SUPERHEATER LOCOMOTIVE FOR THE BELGIAN STATE RAILWAYS.

CONSTRUCTED BY MESSRS. SIR W. G. ARMSTRONG, WHITWORTH AND CO., LIMITED, ENGINEERS, SCOTSWOOD.

(For Description, see Page 772.)

Fig. 6.

Fig. 5.

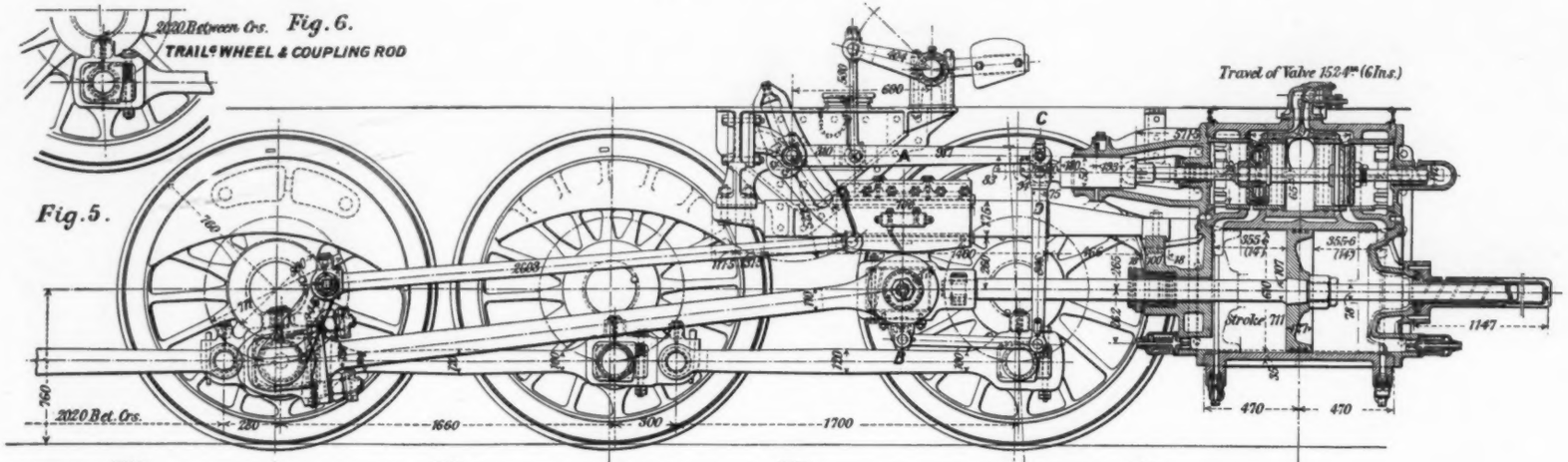


Fig. 7.

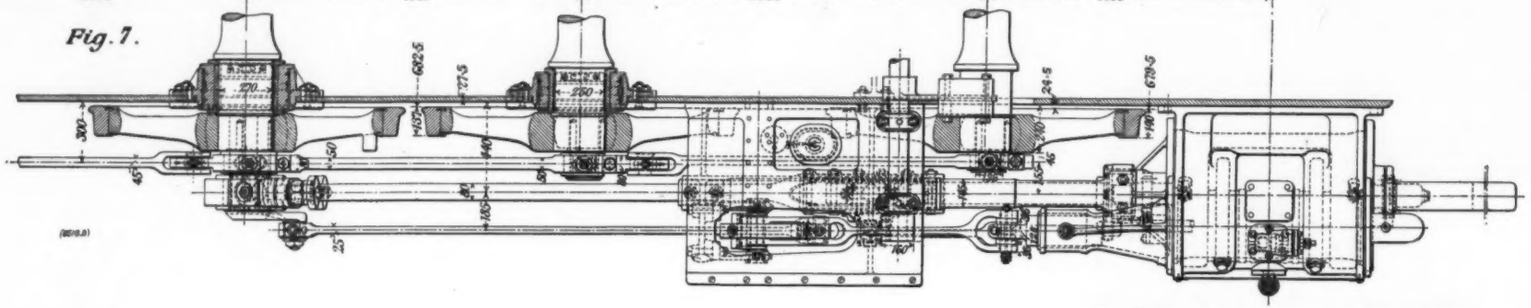


Fig. 10. SECTION ON DRIVING COUPLED WHEEL

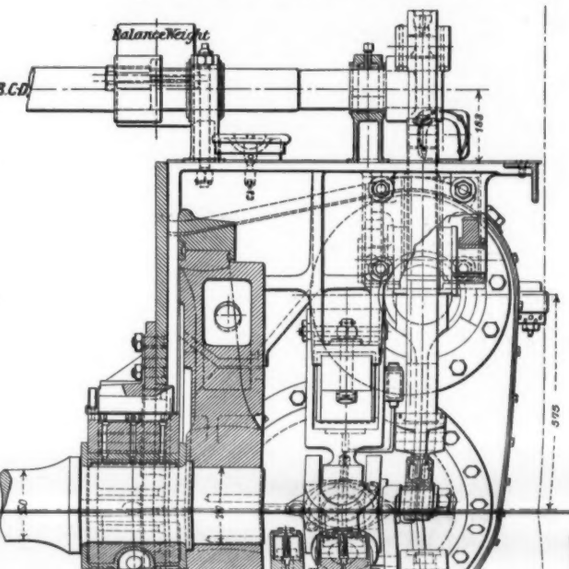


Fig. 8 SECTION OF CYLINDER

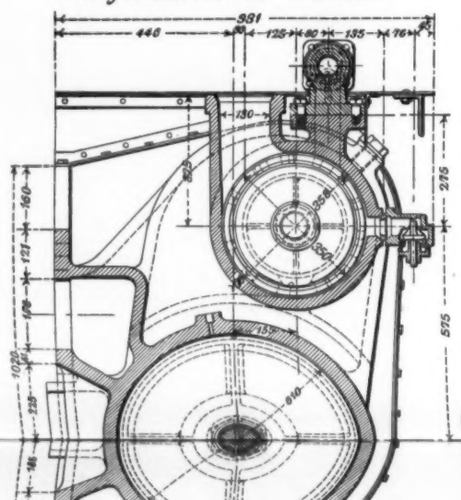
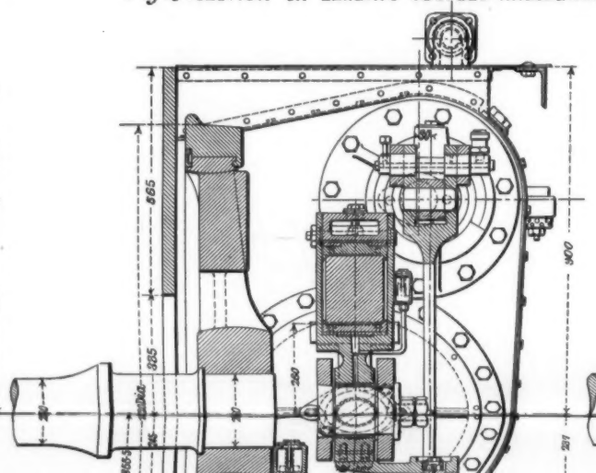


Fig. 9. SECTION ON LEADING COUPLED WHEEL & A-B-C-D



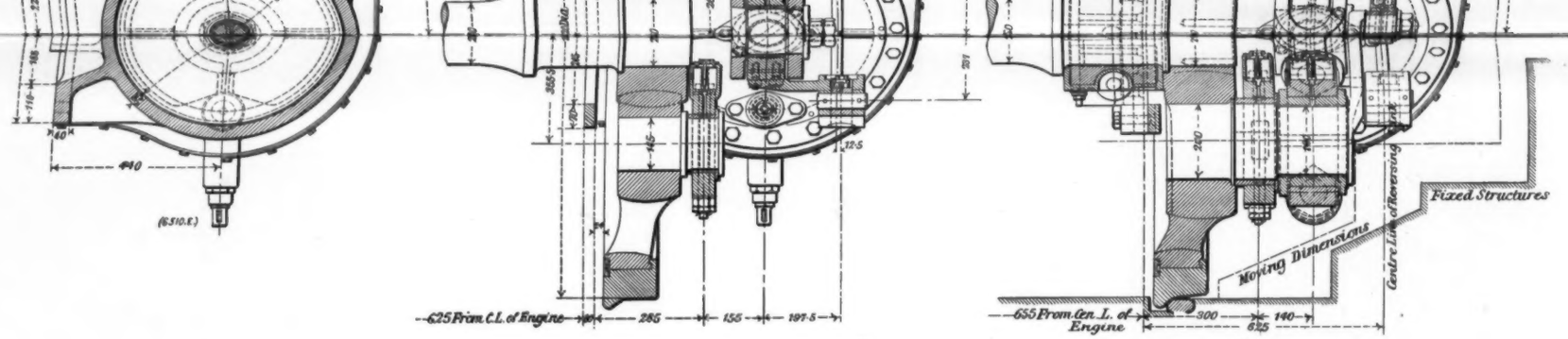


Fig. 11. LONGITUDINAL SECTION

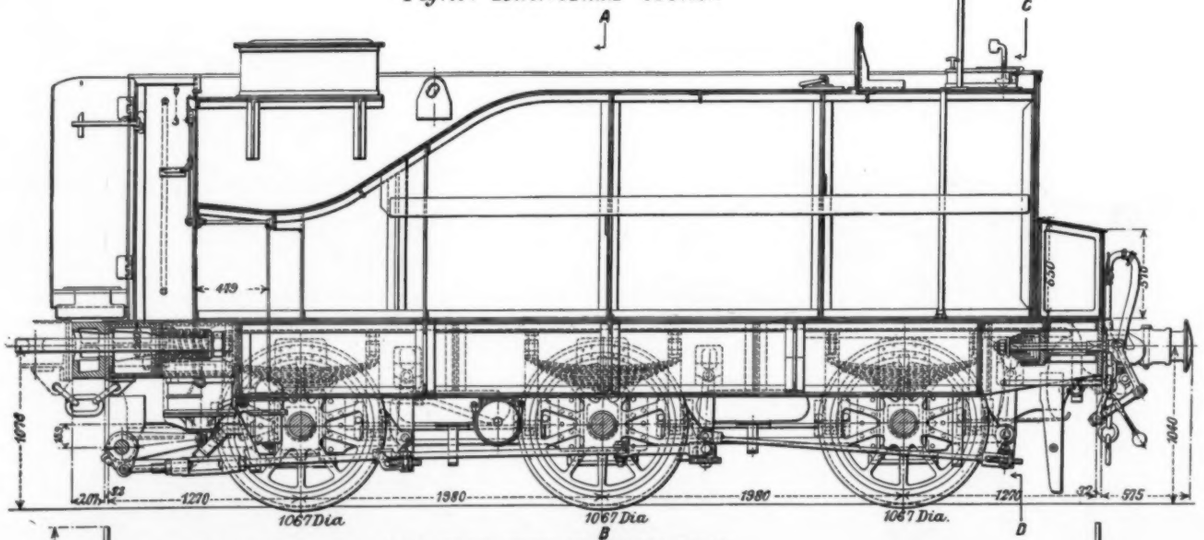
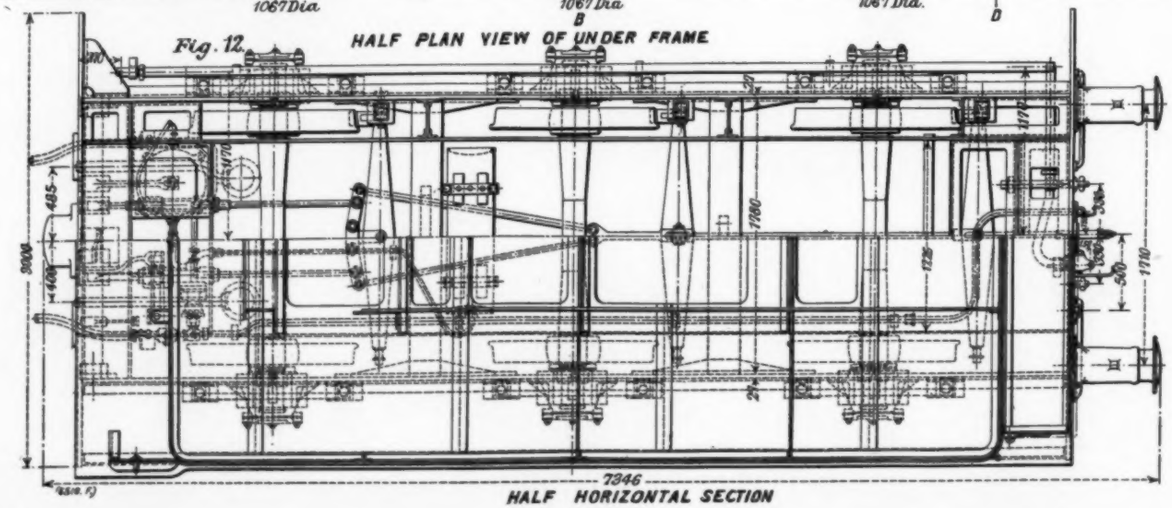


Fig. 12. HALF PLAN VIEW OF UNDER FRAME



HALF HORIZONTAL SECTION

Fig. 13. SECTION A-B. C-D.

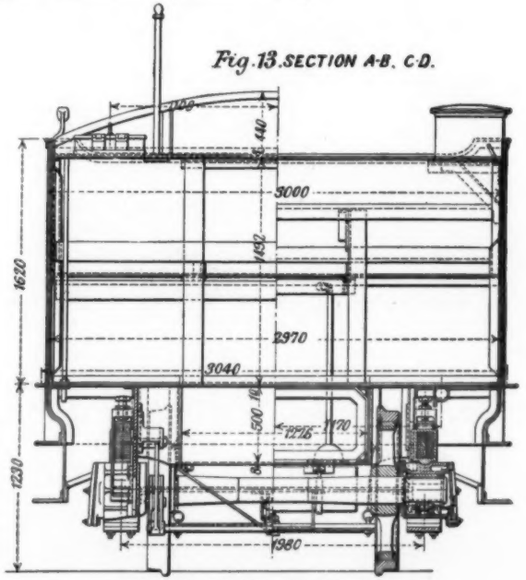
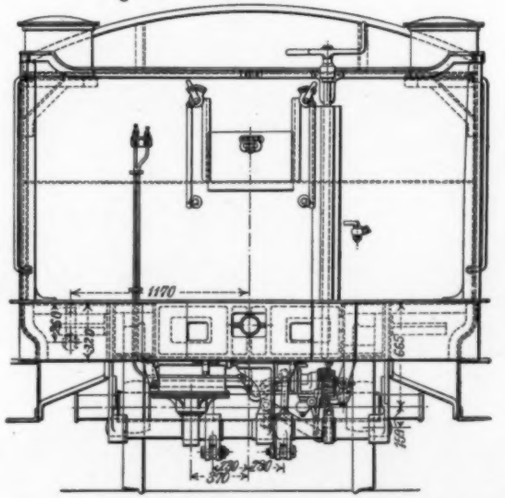


Fig. 14. FRONT VIEW



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NOTICE.

A few months ago the Proprietors of "ENGINEERING" were compelled to advance the price of this Journal to 1s. per copy, owing to the enormous increases in the cost of paper, engravings and printing, &c. Now higher transport and delivery charges involve a further increase to 1s 2d. per copy, and this price dated from and included the issue of Friday, April 2, 1920. As the postal rates have been again increased, the price of single copies sent by inland post is now 1s. 3d.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions still imposed by the Government on the importation of paper and the consequent shortage of supplies, Newsagents will not have copies for chance customers: therefore readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk.

NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 773.

ENGINEERING.

FRIDAY, DECEMBER 10, 1920.

THE ENGINEER GRADUATE.

THE purpose of the technical school and of the engineering side of our universities is to so educate students that they may ultimately become better practical engineers than would otherwise be possible, and the fact that an idea should have grown up that such students after their training are of no value in the workshop suggests that something is wrong. This kind of idea is not as strong as it once was, but it still exists. There are, or have been, faults on both sides. The workshop and the pure workshop man have not appreciated the growing bearing of scientific knowledge in practical engineering affairs, and the technical school, and particularly the technical school student, have not appreciated that examinational knowledge need not, and probably will not, be of direct assistance in dealing with the thousand practical problems which have to be tackled in the workshop day.

We have no intention at the present moment of dealing with the question of engineering education in its broad lines, or of the advantages or otherwise of college work before shop work, shop before college and so on. Taking things as they are, however, we find an enormous number of young men attending courses in engineering at our many universities and schools, and of whom a very considerable proportion have had no practical experience, or opportunity for practical knowledge. These young men are the engineers of the future, and if, without interfering with their theoretical training, it is possible to put them a little more closely in touch with practice the advantage will be obvious, and we think the educationists of no school are likely to be offended. As we understand affairs this is one of the ideas underlying the inauguration of the "student visitor" class in the Institution of Mechanical Engineers. Any matriculated student of an engineering college, if his age lies between 16 and 19 years, is eligible for this class. If he joins he receives the proceedings and may attend the meetings of the Institution.

Considered only from the aspect we have mentioned, it is obvious that this arrangement might be productive of much good. It is hardly to be suggested that the student would understand the whole of every discussion at the meetings (there are probably few adults who do), but in many cases he would receive direct instruction and in others he would be brought in touch with an entirely new point of view which might help to correct the necessarily somewhat one-sided presentment of the technical school. The matter has a further aspect, however. The student engineer is the working engineer of the future and, if the Institution is to progress as it should, he is its future associate member and member. For the good of the Institution it is very desirable that the engineer should become attached to it in his student days. If he does, his attachment is likely to become closer than if he joins in later years, and a membership largely made up of men whose association dates from early life will gain in strength from the fact.

Although this scheme of student visitors appears a good one in every way, and although the scheme has now been in operation for some few months, we understand that so far not a single candidate has appeared. The reason for this might be explained in various detailed ways, but in the long run we think the matter must be explained by the lack of a general appreciation of the existence of the scheme. It has not been sufficiently advertised. We have during recent weeks heard much of the beneficence of advertising, and without subscribing to every detail of the floriferous essays to which we have been treated, it may be admitted that there is a good deal in it. The word advertisement has achieved a flavour which in this country is not usually associated with our graver technical institutions, but if one is prepared to consider means and methods by which the wants or wishes of such an institution may best be brought to the notice of its members and others, one is engaged in considering a scheme of advertising, and it will save time and enable one to get to business if this is frankly admitted.

That the Institution of Mechanical Engineers has appreciated the value of advertising, or publicity work, or whatever euphonic alternative name the more old-fashioned members may care to call it, was illustrated very clearly last Monday evening when the Council of the Institution gave a dinner to the engineering professors of London. This function was not apparently directly connected with the subject of student visitors, but its object was so closely allied thereto that it was almost one with it. The purpose of the dinner was to give an opportunity for the council and the professors together to talk over the question of the graduate members of the Institution with the very definite object of increasing their number. Anything we have said about the advantages of college students becoming connected with the Institution applies with even greater weight to those students who have reached an age which justifies the Institution in accepting them as graduates. The connection they thus make with the Institution is closer than is possible for student visitors; they have their own section, their own meetings and their own organisation. These privileges naturally add to the interest of their position, and the training in the corporate life of the Institution which they receive is likely to serve both them and it in good stead. Particularly from the Institution's point of view is it desirable that these future members should be caught young.

At the dinner of which we have spoken, Mr. Fanghaenel, the recent chairman of the Graduates' Association, stated that while before the war the association numbered 650 members, the figure had fallen to 320 by the end. The present membership was 460. The decrease in strength of this body during the war was only to be expected. A large proportion of its members and potential members were engaged on graver matters than even that of the future status of the Institution of Mechanical Engineers, while on the face of it the rise in membership since the termination of the war of from 320 to 460 may possibly be considered fair progress. There is a less satisfactory side to the picture, however. Mr. Fanghaenel stated that a large proportion of the recent increase had been obtained owing to the efforts of Mr. Edwards, the secretary of the association, and that a large proportion had been recruited from the City and Guilds Engineering College. Before these members were obtained an examination of the lists showed that only 70 graduates were resident in London.

It will be clear from the figures given that there should be a large reserve of potential graduates in the engineering colleges of London, and for the good both of the Institution and these students themselves it is very desirable that the possibilities of membership should be brought to their notice. We think it safe to say that a very large proportion of the engineering students of London have but the vaguest idea of the work of the Institution of Mechanical Engineers, and the place which they themselves might take in it and the best way in which information relative to the matter may be

disseminated among them is certainly through the agency of their various engineering professors. We do not know what proportion of the members of teaching staffs who assembled on Monday evening were themselves members of the Institution of Mechanical Engineers. Certainly all were not, and the function may have succeeded in obtaining a few extra members for the Institution from among the teachers themselves. The main object, however, was more important and should do good in bringing to the professor's attention the claims of the Institution and its right to their interest and influence in extending a knowledge of its work and functions among their students.

There is, of course, no reason why this form of propaganda should be confined to London, but London is certainly the best area in which to make a start owing to the ground covered and the fact that, being the headquarters of the Institution, the main part of the meetings are held there. It is to be hoped that the function of Monday last may cause a fair proportion of the engineering professors of London to take the same interest in this matter which has been evidenced by Professor Dalby, and that a very considerable increase in membership of the Graduates' Association may result. There is, we think, a feeling abroad that the Institution of Mechanical Engineers does not quite hold the position which its importance entitles it to. Some indication of the existence of this feeling was given by Captain Sankey, the president, in the course of his remarks at the dinner. As is generally known, the Institution is taking various steps to stimulate interest in its proceedings and to increase the scope of its activities. We need not enter into details of these matters now, but it is clear that this movement in connection with the strengthening of the Graduates' Association is not the least valuable of the moves which are being made.

THE LABOUR EXCHANGES.

The reports of the committee which was recently appointed by the Ministry of Labour "to examine the working and administration of the Employment Exchanges in Great Britain, and to advise as to their future," have now been published and contain many points of interest to employers. The majority report is signed by all the members of the committee except Sir Charles Sykes, M.P., who has presented a separate report.

It appears that the Exchanges have had from the beginning a troubled existence. They were first opened in 1910, and in the following year they had to commence to administer the Unemployment Insurance Scheme. During the war a great deal of extra work fell upon them, for example, the enrolment and transfer of war munition volunteers and other workers under the special labour enrolment schemes, and the enrolment of the great majority of the women who joined the Women's Service Corps. During the demobilisation period they had heavy work in connection with the re-absorption in normal industry of men and women from the forces, and they had also to administer the out-of-work donation. It may therefore be said that they have never really had time to settle down properly, and this may help to account for some of the unsatisfactory features to which the report draws attention.

The statistics for the first six months of the year 1920 show that the exchanges were receiving registrations by workpeople at the rate of about 3,000,000 per annum and notifications of vacancies by employers at the rate of 1,500,000, and were filling about 1,000,000 places per annum. The committee regard the last figure, representing about 3,000 vacancies filled each day, as unsatisfactory, and they state that the exchanges have not succeeded in displacing, so far as was expected, other methods of finding work, and they are not generally popular. They have not been fully used by highly-organised labour or by the highest grades of unorganised labour, as the men prefer to get situations through their unions or through personal touch with employers or foremen, or comrades in the workshops, and generally use the exchanges only as a last resort; but in the less organised and the unskilled trades the exchanges have been of more value.

The cost of the exchanges has risen from 157,000*l.* for the financial year 1910-11 to 3,613,000*l.* for the year 1919-20, but as their work includes unemployment insurance administration and other activities, it is not possible at present to say what is the average cost of filling each vacancy. At the end of October, 1920, the total staff numbered 5,027, and the committee inclines to think that the central and divisional offices are too costly and cumbersome, and recommends that the whole staff should be reviewed with a view to any necessary reorganisation.

One of the main questions which the committee had to consider was how the unemployment insurance scheme could be administered if the exchanges were abolished. They consider that the ideal system would probably be that each industry should carry its own insurance, but contracting out of the Act by means of special schemes is a most complicated and difficult matter and in the meantime the attainment of this ideal is impracticable. The committee's general conclusion is therefore that the exchanges must be retained, as a national system, that they are a necessary corollary to the State system of unemployment insurance, and that in the interests of national economy they should be made fully effective for their purpose.

It has been frequently complained that the staff who interview and register the workpeople and select them for the vacancies are lacking in the necessary technical knowledge of the industries with which they have to deal. The committee think the complaint is justified, and they recommend that the method of recruiting the staff should be revised and improved, and salaries should be offered such as to attract a good type of candidates with the necessary knowledge. They are also in favour of specialised exchanges for particular industries.

The committee are inclined to think that too much labour is expended at the exchanges in the filling up of forms and the preparation of statistics, and that this should be curtailed. The exchanges have been hampered by the want of suitable premises and the committee state emphatically that the use of unsuitable buildings is not an economy.

Sir Charles Sykes, in his report, criticises the majority report as dealing too much with matters of detail as against the vital principle at issue, namely, public expenditure in relation to value for services rendered. He considers that the exchanges have not fulfilled the expectations of Parliament, although the failure lies more with the system than with the staff, and if it were not for the necessity of administering unemployment insurance he would recommend the immediate curtailment of the exchanges and their restriction to unorganised workers. The difference between Sir Charles Sykes and the rest of the committee is more apparent than real, and his report is rather taken up with ideal solutions of the various problems than with practical matters. He says truly that the real problem is the better organisation of industry and the development of the whole of our financial, commercial and industrial resources throughout the world, and that this can be done intensively only by the trades themselves; and, as regards unemployment insurance, he proposes that all the large and well-organised industries of the country should be asked and assisted to work out special schemes of their own, but he does not seem fully to appreciate the grave difficulties that this would involve. On the whole, the majority are possibly right in their conclusion that, at least in the meantime, the insurance must be administered by the exchanges, but we trust that before long even this excuse for their continued existence may be removed.

CO-OPERATIVE PRODUCTION.

Engineers were among the first sections of the community to realise, and call attention to, the fact that the first essential for the restoration and improvement of the industrial prosperity of pre-war times was a greatly increased production of commodities, and the conviction has now become so general that there is no necessity to urge it further in these columns. Even in labour circles, if we except that section whose only apparent object is to foster class hatred in every possible way, the necessity for augmenting output is more generally understood, since it has become evident that rising wages in conjunction with diminishing production are very far from improving the position of the workers. What, then, are the obstacles which have so long delayed, and which still continue to hinder, the generally desired improvement in our industrial situation? To give a complete answer to this query, even if we were capable of supplying it, would require more space than that at our disposal, but we wish to refer briefly to two factors which profoundly affect the situation, if they do not control it completely.

The first of these, and perhaps the most difficult to eradicate, is the workers' fear that increased production will be followed by unemployment. His view is that there is only a certain amount of work available, and if, by extra effort, he completes this in less than the normal time, his services will be dispensed with. The miseries resulting from a period of enforced idleness, he knows, will far outweigh the advantages to be gained from his increased earnings, and he therefore decides to restrict his output with a view to ensuring continuity of employment. No very advanced knowledge of industrial economics is necessary to see that this attitude is wrong and, if persisted in, may easily lead to the destruction of industry which would be followed by permanent, instead of transitory, unemployment. Even transitory unemployment can undoubtedly be greatly diminished, if not entirely avoided, by proper organisation of industry—organisation which was lacking in the pre-war period when the workers' views were formed. The responsible leaders of labour have no more important duty to their followers, to say nothing of the rest of the community, than to endeavour to make this point clear to the former, and they may derive much help in this endeavour by studying the remarks of Mr. J. R. Clynes, M.P., made at a luncheon given last week by the Higher Production Council. Mr. Clynes, who cannot be said to speak for the capitalist, pointed out that the profiteer and speculator, and not the worker, gained most by under-production, and with regard to the effect of the latter on unemployment he called attention to the fact that, in the year now drawing to a close, restriction of output has certainly not avoided this evil. There can be no doubt that if the workers generally can be convinced of these facts a great step towards the improvement of the industrial situation will have been made.

The other factor, which seems rather easier to deal with, is that the less far-seeing workers assume that the extra efforts they may make to increase production will go wholly, or mainly, to increase their employers' profits. Actually, of course, the workers' own organisations might surely be relied upon to frustrate any intention on the part of employers to secure an undue proportion of the rewards of industry, if such intention existed. A just division of the rewards is now generally acknowledged to be the only foundation upon which permanent industrial peace can be built, and profit-sharing schemes, bonus systems and other methods of remunerating labour have been devised, and introduced very largely in the engineering industry, in order to provide the workers with some incentive to increase output. In general, however, it must be admitted that these systems have failed to secure that reasonable co-operation between capital and labour, or as we would rather put it, between employers and employees, which is essential for industrial peace and national prosperity.

It was in a praiseworthy endeavour to develop industry by the advocacy of suitable methods of payment, and by promoting collaboration between employers and employed, that the Higher Production Council was formed rather more than a year ago. This organisation, which is supported on a purely voluntary basis, is composed of representatives of employers and of trades unions, and its work, so far, has been confined mainly to the furtherance of the Priestman system of co-operative production. We have already referred* to this system, but it may be advantageous again briefly to explain its origin and principles. The system was devised by Messrs. Priestman Brothers, Limited.

* See Engineering, vol. cvi, page 641, and vol. cviii, page 511.

of Hull, and was introduced into their works in the spring of 1917. According to this method a standard rate of production for the factory is fixed by the management and the men's representatives in collaboration, and for this production the standard union rate of wages for the district is paid. Actually the standard rate at Messrs. Priestman's works was increased by 10 per cent. when the system was inaugurated, but this is not in any way an essential feature. The output is reviewed once in every four weeks by a works' committee and the management, and, if the production exceeds the standard by a certain percentage, a similar percentage increase is made in the salaries or wages of the whole of the works staff, from the manager down to the errand boy, for the following period of four weeks. Messrs. Priestman's products consist mainly of dredging plant, and the output is based on the weight of finished machinery. As the deliveries are fairly constant the arrangement of calculating the output for periods of four weeks operates satisfactorily, but obviously modifications in these features would have to be made in applying the system under different conditions.

We do not propose to go into the details of the system since these would also naturally vary somewhat in each case. Neither do we suggest that it can be applied in all possible circumstances, but we may say that it has given complete satisfaction to both employers and men at Messrs. Priestman's, and has resulted in an increase of 50 per cent. in production, as mentioned by Mr. W. D. Priestman at the Institution of Mechanical Engineers on Friday last and reported on page 765 of this issue. It is not difficult to understand how this is brought about when it is remembered that each and every member of the works organisation has a direct incentive not only to increase his own output, but also to assist his fellow-workers to increase theirs. In the systems of payment by results as usually applied there must be a considerable number of workers engaged on repairs, maintenance and special work, as well as salaried officials and office staff, who do not benefit from an increase in production, and the failure to secure the willing co-operation of these men may easily have a notable effect in reducing the output of the whole concern. The absence of this objection from the Priestman system, in our view, is a very important point in its favour, and one which should do much to ensure its success. It is hardly necessary to point out that the advantage to the employers lies in the fact that the standing charges, such as rent, rates, &c., are distributed over a larger amount of work, and also in the absence or, notable reduction, of friction, stoppages, and other difficulties with labour.

It is, of course, too much to hope that the Priestman system alone will prove a universal remedy for all our industrial troubles, but, at the present time, no method of alleviating them should be rejected without very careful consideration. We may also mention that upwards of 100 firms have already in operation, or are about to introduce, systems embodying the principles outlined above, and, if the results achieved in a reasonable proportion of these cases are in any way comparable with those attained at Messrs. Priestman's works, the effect on the industrial position should be noticeable in the not-far-distant future. In conclusion a word should be said in acknowledgment of the efforts of the Higher Production Council, who, during the first year of their existence, have supplied information on the system they advocate to nearly 700 different firms, and have visited over 400 of them. In the cases of 76 firms the adoption of the system can be directly traced to the work of the Council, which therefore justly claims the goodwill and support of all who hope to benefit from the restoration of industrial peace and prosperity.

UNEMPLOYMENT PROBLEMS.

THE recent discussion between the Minister of Labour and a deputation from the National Alliance of Employers and Employed has received so much notice in the daily press that a brief examination of the proposals put to Dr. Macnamara and of his answers may not be without interest. The National Alliance, which consists of certain employers and workers' representatives who endeavour to act as one unit in the interests of both employers and employed without claiming to be generally representative of either, has been considering for some months the state of unemployment in the country, and recently decided to urge the Government to take certain steps to deal with the matter. Its proposals were communicated to the Minister of Labour and formed the subject of this discussion.

The first proposal dealt with unemployment insurance benefit. Under the Unemployment Insurance Act, as it stands, benefit is payable only if a certain number of contributions have been paid and for only a certain number of weeks. The National Alliance asked the Government to pass immediate legislation to enable unemployment benefit to be given although the necessary number of contributions had not been paid, and to suspend until the end of the year the statutory limit to the number of weekly payments of benefit. The Minister of Labour, while sympathising with the wishes of the deputation, replied that he could take no action in this direction. At the same time he pointed out that under the new Act, during the first year of its operation, eight weeks' benefit may be obtained as soon as four weeks' contributions have been paid, although under the Act of 1911 the necessary qualification was 26 weeks' contributions. The deputation recognised that it was impracticable to amend the Act and modified their request to one for a grant from the Exchequer, which, as the Minister pointed out, practically amounted to a request for an out-of-work donation for civilians. To this the Minister replied that he had no authority to deal with such a request, and that the most he could do would be to mention it to the Unemployment Committee of the Cabinet. The deputation stated frankly that they did not like the idea of doles, and much preferred to have the situation dealt with by the provision of employment of some kind.

This led to the second proposition, which was that in cases where schemes or contracts of a sound economic nature, whether under the control of the Government, of municipalities, or of private persons, are held up for the want of labour, the Government should make special arrangements for the supply of available unemployed labour. In answer to this the Minister referred to the negotiations which have now been proceeding for a long time with the building trades in order to enable ex-service men to be taken into them. He also dwelt on the relief measures which have been taken in connection with the making and repairing of roads and sewers. The defect in all these measures, which at best can only be regarded as palliatives, is that there are many classes of workers, as for example, men of poor physique, and great numbers of unemployed women, who would be unable to benefit directly by them.

The third suggestion made was that the Government should call upon each industry to compare its own employment with its nearest normal period, and should urge upon employers and trade unions the need of arranging for the division of available work. Put shortly, this means that employers and trade unions should endeavour to arrange for the employment of as many workers as possible on short time, if need be, rather than of a limited number on full time. The Minister, in replying, expressed his sympathy with this proposal and hoped that employers and employed would endeavour to see how far this practice could be introduced. Short time, he stated, as an alternative to discharges was now organised to a greater extent than ever before. This proposal, viewed from the point of view of the unemployed, has its obvious attractions, but the difficulties in the way of giving effect to it on a large scale are equally obvious. In many works it is hardly practicable, and in others it might unfavourably affect the cost of production. This would react unfavourably on industry and employment. It is obvious that such matters can be settled only by employers and employed, or their representatives. Any ill-directed attempt to force the pace in dealing with them may be disastrous.

The National Alliance is much concerned about the surplus labour which does not belong to any definite trades—the men who may be found unemployed in the streets of every city, and who, when asked what they can do, say "labouring, window cleaning, or anything," which, being interpreted, means that they have no special aptitude or qualifications for any particular occupation. The question how these people are to be usefully employed is perhaps the most difficult of all, and the National Alliance has asked the Government to arrange that any unabsorbed balance of labour be referred to District Councils of employers and trade unionists, who would arrange for temporary measures of employment in conjunction with municipalities and district authorities. A number of municipalities and district authorities who are prepared to co-operate with such councils have been mentioned in this connection. The Minister apparently regarded his remarks with reference to the work which is being done in conjunction with local authorities on roads and sewers as covering this part of the subject.

It would be ungracious not to recognise the sincere desire of the National Alliance to improve the present situation, but it may be doubtful whether this conference will have much practical result.

NOTES.

STANDARD MARINE BOILER RULES.

A NEW set of standard conditions for the design and construction of marine boilers has just been issued by the Board of Trade, which reduces to a commendable degree of uniformity the requirements hitherto in vogue. These rules are the outcome of the work of a conference called under the auspices of the Board of Trade, on which that body, Lloyd's Register of Shipping, the British Corporation for the Survey and Registry of Shipping, and the Bureau Veritas International Registry of Shipping, were each represented by three experts. The names of the members of this conference are a guarantee of the value of the work, and of the care which has been put into the formulation of the new conditions. The new rules are based on the recommendations of the British Marine Engine Design and Construction Committee, and it is satisfactory to think that the formation of this committee, which, though not originated by, had the active support of, the Institution of Naval Architects, has now resulted in a uniform code. It will be remembered that at the spring meeting of the Institution of Naval Architects in 1919, Mr. A. E. Seaton read a paper on the work of this committee and appealed to the Board of Trade to take the matter up. Not only this paper but the discussion upon it showed how anomalous the situation was, and it must be a considerable source of satisfaction to those who took the early steps in this matter that good has resulted from their efforts.

THE USE OF NAPHTHALENE SOLUTIONS IN INTERNAL-COMBUSTION ENGINES.

The combustion of naphthalene solutions in internal-combustion engines formed the subject of a paper read on Wednesday last before the Institution of Automobile Engineers by Mr. L. S. Palmer, M.Sc. The investigation with which this paper was concerned was due to a desire to employ fuel of higher calorific value than the ordinary motor fuels, and attention was first directed to dissolving acetylene in the fuel. This, however, was abandoned, and the experiments were conducted with naphthalene dissolved in benzol. Road tests were carried out on a motor bicycle specially fitted, and bench tests were made in the Automobile Laboratory of the University of Bristol, the expenses being borne by the Colston Research Fund of the university. Difficulty was encountered with keeping the naphthalene dissolved in the case of benzol solutions with much over 15 per cent. of dissolved naphthalene, with changes of temperature, and trouble arose with the carburettor. The investigation suggests that with 15 per cent. solution the fuel is economically efficient for petrol motors, giving about 3·4 per cent. more mileage than commercial benzol, at about 3d. less per gallon, at present prices. These figures, though favourable, are not large, and they indicate that little is really to be gained except in the matter of price, which it must be admitted is worth considering. There appears to be little trouble with the combustion of slightly richer solutions, but the fact that they are

not stable in the carburettor renders their use impossible. A solution of benzol containing 15 per cent. of naphthalene has a calorific value about 3·3 per cent. above that of the benzol itself.

The Subscriptions to Scientific Institutions.

One is much inclined to judge the conduct of the individual by reference to his own past preformance rather than by relation to the general average. Charles Lamb, who used to make up for coming late to the office by going away early, had no doubt by gentle persistence established a prescriptive right in this performance, so that it was taken as a matter of course; while probably some of his co-workers who were model time-keepers would be called upon for explanation even of a minor lapse. This may be speculative, but one has a modern and recent case showing the same partiality in the general judgment. No one needs to be reminded that the value of money has depreciated something considerably more than 50 per cent. in recent years. The price of most commodities followed this depreciation rapidly enough, but as the cost of local railway and omnibus travel in London lagged behind somewhat in relation to the value of money, an unformed opinion appeared to be created holding that this commodity was not a proper subject for the common increase in price. The very virtue of holding off increase of fares for so long was made cause of offence, and there is little doubt but that had the increases been put through earlier they would have met with less opposition. The latest organisations to suffer in the same way from their own well-meaning efforts are various technical institutions. These bodies, like others, have at last had to realise that a penny is not a penny and is not even a halfpenny, with the obvious consequence that they have had to raise their subscription rates. Instead of being praised, however, for holding off so long, they have been criticised for bringing the matter forward even now. The only shallow comfort one can give is to say they should have done it earlier. No one likes to have these subscriptions raised, but the matter needs no defence. The latest body to carry an increase through was the Society of Engineers who secured the desired advances on the 3rd inst., while on the 2nd inst. the Institution of Electrical Engineers was also successful. In this case, however, there was considerable opposition, and the matter was not accomplished in less than two and a-half hours. As it was finally carried, however, the Council would probably consider the time well spent. The Institution of Mechanical Engineers obtained sanction for a corresponding increase some two months ago, and satisfactory advances have also been agreed to by the members of the Institute of Metals and the Iron and Steel Institute. It may safely be said that increases of subscriptions have become an absolute necessity if our technical institutions are to carry on their work with efficiency, and the members will do well to recognise this fact.

The National Physical Laboratory.

Sir Joseph Petavel, director of the National Physical Laboratory, held a reception last Wednesday evening, giving his guests a welcome opportunity of seeing some novel demonstrations in the Heat Division, the X-Ray Department and the Optical Division, these departments being thrown open. In the Heat Division the new devices for determining humidity in connection with cold storage claimed chief interest. The wet and dry bulb thermometers, and the dew-point hygrometer are not direct-reading, nor suitable for working below freezing-point, as was demonstrated in various ways, and none of them are distant-reading instruments. Two types of measuring instruments have been worked out. In the one a film of cigarette paper is wetted with glycerin and applied to the face of the glass prism of an Abbe refractometer; the refractive index of the glycerin in the film decreases as the humidity increases. The other instrument is based upon the fact that heat is evolved when moisture is condensed on cotton wool. To utilise this fact two nickel coils are wound on an ebonite frame; the fine nickel wires are both wound with cotton, but the cotton of the one coil is bare, that of the other covered with shellac; on the latter no condensation takes place. The two coils form arms of a Wheatstone bridge. The instrument consists of two vertical tubes, about 2 in. diameter, through which air is driven by bellows worked by an electric motor; the air in the one tube is dried, that in the other kept saturated with moisture, and a valve sends over the coils either room air, or dried air, or moist air, so that the coils are being dried or moistened by the air currents. This seems to be a very useful instrument. It was also shown that when hot plates are arranged like book shelves, one above the other, and horizontal baffles of cardboard are projecting from the shelves, the convection currents are only modified, not really stopped, even when the space between the baffles is packed with cork. The Optical Department demonstrated the use of novel devices for investigating the sensitivity and personal equation errors of various types of optical settings. The apparatus for testing the polishing and silvering of mirrors is strikingly simple. It is a photometer bench; balance is first established between the standard lamp and a second lamp which can be burned in the horizontal plane of a disc, in the centre of which the mirror is mounted. By swinging the second lamp round, reflection from the mirror is obtained at any angle of incidence, and the amount of light reflected is measured by sliding the standard. The instrument thus works without any accessory mirrors or prisms.

TIDAL POWER DEVELOPMENT.

By Professor A. H. Gibson.

Although the idea of utilising the rise and fall of the tides for power purposes has long been a favourite one, no tidal power scheme of any magnitude has yet been developed in any part of the world. The lack of data based on operating conditions and on constructional costs renders it difficult to form any definite conclusions as to the economic aspects of such a scheme. Much interest is, however, being shown in this question by Government committees in Great Britain and in France. It is reported that experiments are to be carried out in the latter country, and it is probable that definite data will be available in the near future.

The only practicable methods of developing tidal power on any large scale are based on the use of one or more tidal basins, separated from the sea by dams or barrages, and of hydraulic turbines through which the water flows on its way between the basin and the sea, or between one basin and another.

As will be seen, the power which may be developed from a tidal basin of given area, depends on the square of the tidal range, and since the cost per horse-power of the turbines, generating machinery and sluice gates increases rapidly as the working head is diminished, the cost per horse-power of a tidal installation, other things being equal, will be smallest where the tidal range is greatest. For this reason the south-western coasts of Great Britain and the western coast of France are particularly well adapted for such developments, since their tidal range is greater than in any other part of the world, with the possible exception of the Bay of Fundy, Hudson's Bay, and Port Gallelos in Patagonia.

Tidal Range.—In the great oceans, remote from land, the tidal range varies from approximately 2 ft. at spring tides to 0·75 ft. at neap tides. As the tidal wave enters the shallow waters near land, its height is increased. For example, round the coast of Great Britain, the average range at springs is 16·4 ft., and at neaps 8·6 ft. The configuration of the land affects the range considerably. Where the tidal wave reaches a given point by two routes, as, for example, on the eastern coast of Ireland, where the tide is due to influx from the Atlantic partly around the north, and partly around the south of the island, the resultant tide is compounded of the two, and its range may be either large or very small, depending on the difference of phase between them. If the high tide of the one coincides with the low tide of the other, the resultant may be practically zero.

The configuration of the coast line also affects the range considerably. Where the tidal wave enters a long converging estuary, its momentum causes a large increase in its height, and this is responsible for the large tidal ranges at such points as Portishead in the Severn and St. Malo, where the average ranges at spring tides are approximately 42 ft. and 37 ft. respectively.

The following table shows the approximate values of the mean tidal range at various points.

Locality.	Springs.	Neaps.
Severn—		
Portishead	42·0	21·5
Chepstow	38·0	19·0
Bridgewater Bar	35·0	18·0
St. Malo	37·0	15·5
Boulogne	30·5	—
Dee	26·0	12·0
Liverpool	27·5	13·0
Le Havre	25·0	—
Brest	23·5	—
Beaumaris	23·5	10·0
Amloch	20·0	11·0
Thames—		
Southend	15·5	10·5
Sheerness	16·0	10·5
London Docks	19·0	—
Putney	10·0	—
Kew	7·0	—
Richmond	4·0	—
Tay (Dundee)	14·5	8·5
Montrose	14·0	8·0
Harwich	13·0	10·5
Chester	10·0	—
Orford Ness	8·0	6·5
Lowestoft	6·5	5·0

The heights of the spring and neap tides vary appreciably during the year. The highest springs normally occur at the beginning of April and the lowest neaps about the end of February. The highest springs are approximately 15 per cent. higher and the lowest neaps 25 per cent. lower than the mean springs and neaps. The heights may moreover, be greatly affected by a strong wind, so that in any tidal installation a possible variation of at least 25 per cent. from the mean should be allowed for.

The time of a complete tide is approximately 12¼ hours. The rising tide usually occupies a smaller interval of time than the falling tide, the flow usually taking about 5¾ hours, and the ebb about 6¾ hours. Much, however, depends on the range of the tide and on the physical configuration of the coast, and in a long estuary this inequality of times may be even greater. Thus in the Severn at Chepstow the ebb occupies 7·5 hours on a spring tide and 6·5 hours on a neap tide.

The great difficulty in the way of the commercial utilisation of a tidal scheme, as compared with an orthodox low head inland water power scheme, arises from the relatively great fluctuations in head. In any scheme in which the working head is a definite fraction of the tidal range, the working head at spring tides is much greater than at neap tides. In the case of the Severn, for example, the working head at springs would be twice as great as at neaps, and the energy output per tide would be four times as great at springs as at neaps, while at St. Malo the output would be 5·7 times as great at springs as at neaps.

Not only is the installation subject to this cyclical fluctuation of head, but, in any simple scheme, the turbines cease to operate for a more or less extended period on each tide, and as this idle period depends on the time of high or low tide it gradually works around the clock, and will, at regular intervals, be included in the normal industrial working day. It is true that schemes of operation are feasible in which this idle period may be eliminated, and continuous operation may be ensured, but only at a considerable reduction of output per square mile of tidal basin area. Even in such schemes, unless the working head is fixed with reference to the tidal range at neap tides, in which case only a small fraction of the total available energy is developed, the variation of head between springs and neaps causes the output to be very variable.

In any installation then, designed for an industrial load, some form of storage system forms an essential feature of the scheme unless the output is cut down to that obtainable under the minimum head available at neap tides, in which case only a very small fraction of the total available energy is utilised,

and the cost of the necessary engineering works per horse-power will, except under exceptionally favourable circumstances, be prohibitive.

Various storage systems have been suggested. Electrical accumulators must be ruled out, if only on account of the cost, and the same applies to all systems making use of compressed air. The most feasible system appears to consist of a storage reservoir above the level of the tidal basin. Whenever the output of the primary turbines exceeds the industrial demand the excess energy is utilised to pump water into the reservoir, and when the demand exceeds the output from the primary turbines it is supplied by a series of generators driven by a battery of secondary turbines operated by the water from the storage reservoir.

Evidently this method is only available when the physical configuration of the district affords a suitable reservoir site within a reasonable distance of the tidal basin. Unfortunately, also, considerable losses are inevitable in the process. If the

Efficiency of primary generators ...	= 0·95
Efficiency of transmission to pump motors	= 0·95
Efficiency of pump motors	= 0·95
Efficiency of centrifugal pumps ...	= 0·77
Efficiency of pipe lines to and from reservoir	= 0·95
Efficiency of secondary turbines ...	= 0·80

the combined efficiency is only 50 per cent., and the energy available for continuous distribution will only be about 60 per cent. of the output of the primary turbines, the exact proportion depending on the working period per tide and on the relative range of spring and neap tides.

Where two tidal schemes at some distance apart differ sufficiently in phase, it is possible by working the two in conjunction, to reduce or eliminate the idle period between tides, and thus to reduce the necessary storage somewhat, but this does not affect the necessity of storage as between spring and neap tides.

Since storage reduces the available output by about 40 per cent., and at the same time complicates the system, besides adding considerably to the first cost and maintenance charges, the prospects of tidal power schemes would be much more promising if the whole of the output could be utilised as generated. By feeding into a distributing main in conjunction with a large steam station and (or) inland water power scheme, and delivering to an industrial district capable of absorbing a comparatively large nightload, such a state of affairs might be realised, at all events approximately. There is also the possibility that the intermittent operation of certain electrochemical processes may be developed so as to enable any surplus power to be absorbed as and when available, and if so tidal power developed under favourable conditions, will probably prove at least as cheap as power obtained from any other source.

Schemes of Development.—Many schemes of tidal power development have, from time to time, been suggested. Briefly outlined, the more promising of these are as follow :—*

(*a*) A single tidal basin is used, divided from the sea by a dam or barrage in which are placed the turbines. The basin is filled through sluices during the rising tide. At high tide the sluices are closed. When the tide has fallen through a height whose magnitude depends on the working head to be adopted, the turbine gates are opened and the turbines operate on a more or less constant head until low tide or slightly after. If A be the surface area of the basin in square feet; if H ft. be the tidal range; if a constant working head of x ft. be adopted; and if the turbines operate until low tide, the volume passing through the turbines during the falling tide will be $A(H - x)$ cub. ft., and the energy available in the water will be

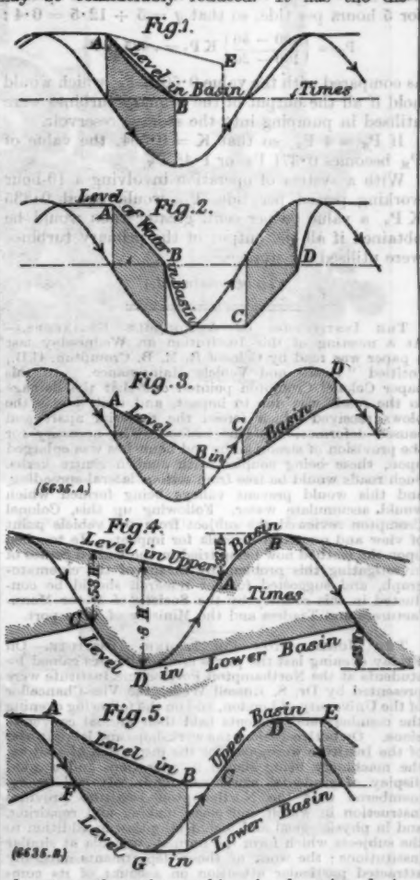
$$64\,A \times (H - x) \text{ ft.-lb. per tide.}$$

This expression is a maximum when $x = H \div 2$, that is, when the working head equals one-half the tidal range, and then equals $16\,A\,H^2$ ft.-lb.

If A is in square miles, and if the efficiency of the turbines is 75 per cent., the output in horse-power hours per tide is given by

$$\frac{0{\cdot}75 \times 64 \times (5280)^2\,A\,H^2}{4 \times 33000 \times 60} = 169\,A\,H^2$$

The cycle of operations is shown in Fig. 1, where A B denotes the working period and C D the period of replenishment of the basin. Owing to the great variation in the rate of efflux of the water in this constant head method of operation, the power output varies very largely during the falling tide. This variation may be reduced considerably by arranging the turbines to operate on a more or less constant fall of level in the basin as shown by the full line A B. By this method of operation the necessary turbine capacity for a given output may be considerably reduced. It has the disadvantage that the working head varies during the tide, but this is more than counterbalanced by the advantages. By extending the working period beyond low tide, as indicated by the dotted line A E, a greater amount of energy may be developed per tide and the idle period is diminished, but at the expense of an appreciably greater variation in head. The most efficient combination of working period and of working heads can only be determined by detailed examination of the particular site, and with a knowledge of the exact form of the tidal curve.



(*b*) A single tidal basin is used, with the turbines operating on both rising and falling tides. The cycle of operations is indicated in Fig. 2. The working period per complete tide now extends from A to B and from C to D. Slightly before low water, at B, the basin is emptied through sluice gates, and at D, a little before high water, the basin is filled through the sluice gates. With a working head equal to one-half of the tidal range, the period of operation is approximately 50 per cent. greater than in system (*a*) with operation down to low tide, and the work done per complete tide is approximately 50 per cent. greater.

(*c*) A single tidal basin is used with the turbines operating on both rising and falling tides. Instead of filling and emptying the tidal basin through sluice gates at high and low water and working under an approximately constant head, the water is allowed to flow through the turbines and to adjust its own level. Under these conditions the rise and fall inside the basin is cyclical, with the same period as the tide, but with a smaller rise and fall and with a certain time lag. The range in the basin and the time lag depends on the ratio of the surface area of the basin and of the effective discharge area of the turbines. The working head during each tide varies from zero to maximum. The cycle of operations is shown in Fig. 3. The working period is from A to B and from C to D, where the head at the points A, B, C and D is the minimum under which the turbines will operate. The total working period per tide is greater than with either of the preceding systems, and the possible output is somewhat greater. On the other hand the variation of head during any one tide is very large.

(*d*) Two tidal basins of approximately equal areas are used, with turbines in the dividing wall. Each basin communicates with the sea through suitable sluice gates. In one of these basins, called the upper, the water level is never allowed to fall below one-third of the tidal range, while in the lower basin the level is not allowed to rise above one-third of the tidal range. The working head then varies from 0·53 H to 0·80 H, with a mean of approximately 0·66 H, and operation is continuous as indicated in Fig. 4, which shows the cycle of operations. Between A and B, the upper basin is filled from the sea through appropriate sluice gates and the lower basin discharges into the sea from C to D. For a given total basin area and a given tidal range, the output is only about one-half that obtained in system (*a*) and one-third that obtained in systems (*b*) and (*c*), so that except where the physical configuration of the site is particularly favourable, the cost per horse-power is likely to prove very high.

(*e*) Two tidal basins of approximately equal areas are used. Turbines are installed in the walls dividing the sea from each basin. Fig. 5 shows the cycle of operations. From A to B the upper basin discharges through its turbines into the sea. From B to E the sea enters the lower basin through its turbines. The upper basin is filled from the sea through its sluice gates between C and D, and the lower basin is emptied through its sluice gates from F to G. The head varies from 0·25 H to 0·62 H, and the output is some 25 per cent. greater than in system (*d*), but the number of turbines required is much greater than in (*d*).

It is possible, at the expense of additional complication, to arrange in each of these systems, that the head shall be maintained constant during any one working period, but since this means that the working head is then limited to the minimum obtaining during the period, a loss of energy is involved, with a great additional cost of construction and complication in manipulation and with little compensating advantage.

For any scheme of development involving the use of a tidal estuary, of such a type as is found in the Severn or Dee, the cost of any of the multiple basin systems would appear to put them definitely out of count. The only schemes worthy of serious consideration appear to be those based on the use of a single tidal basin, developing power either in the outflowing tide only, or on both rising and falling tides, and with the turbines coupled to generators which deliver directly into the distributing system when the demand permits of this, and which, at other times, supply the motors of a pumping station supplying water to an elevated reservoir, for which a secondary system of turbines is supplied, as required, under a constant head. The following investigation is confined to these types of development.

The investigation is based on the assumptions that :—

(*a*) The area of the tidal basin is 1 sq. mile, and that the water surface is sensibly level at all stages of the tide, so that the product of the surface area and the change of level at the dam gives the volume leaving or entering the basin per tide.

Actually in any given case, the area will usually be less at low than at high tide, while in a long estuary the rise or fall immediately above

* For a resumé of the various systems which have been suggested and patented in the past, reference may advantageously be made to a series of nine articles by E. Maynard, *Revue Générale de l'Électricité*, November 2, 1918, and following issues.

the dam will be appreciably greater than the mean rise and fall in the basin. A contour survey of the basin, along with simultaneous gauge readings at different stages of the tide and at different points in the basin, enables both these factors to be taken into account.

(*b*) The curves for the rising tide and for the falling tide are portions of sine curves. The range at spring tides is 42 ft., and the rising tide occupies 5 hours and the falling tide 7·5 hours. The range at neap tides is 16 ft., and both rising and falling tides occupy 6·25 hours.

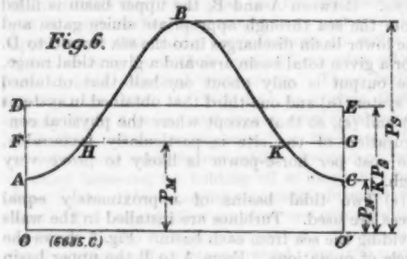
(*c*) The curve showing the variation of tidal range over a lunar cycle is a sine curve.

(*d*) The output of a given turbine with a given gate opening is proportional to $h^{\frac{1}{2}}$, where h is the working head.

(*e*) The mean efficiency of the primary turbines is 75 per cent.

(*f*) *Mean Output during a Lunar Cycle.*—When the tidal range for each day during a lunar cycle is known, and the working period and mean head for each day has been settled, the output in horse-power hours per tide, from the primary turbines, may be determined, and a curve may be plotted on a base representing the number of tides, to show the output per tide, as in Fig. 6. The mean height of this curve represents the mean output of the primary turbines over the lunar cycle.

Fig. 6.



Assuming the curve representing the tidal range to be a sine curve with a mean height of H, and a fluctuation of $\pm$ h, and assuming the working head to be proportional to the tidal range, the output per tide with a given turbine capacity will will be sensibly proportional to the square of the tidal range, and, for any particular tide, will be equal to

$$k\,(H + h \sin \theta)^2 \quad . \quad . \quad . \quad (1)$$

where k is a constant.

The mean output, over the lunar cycle, will then be equal to

$$\frac{k}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} (H + h \sin \theta)^2\, d\theta \quad . \quad . \quad . \quad (2)$$

$$= k\left\{H^2 + \frac{h^2}{2}\right\} \quad . \quad . \quad . \quad (3)$$

If the output in horse-power hours during a spring tide be represented by P_S, and during a neap tide by P_N, we have

$$P_S = k\,(H + h)^2,\ P_N = k\,(H - h)^2,$$

and on substituting in (3) for H and h in terms of P_S and P_N, the mean output of the primary turbines, over the whole cycle, becomes

$$\frac{3\,(P_S + P_N) + 2\sqrt{P_S P_N}}{8} \quad . \quad . \quad \text{H.P. hours.}$$

$$= K P_S \quad . \quad . \quad . \quad \text{H.P. hours.}$$

If, for example, the tidal range at springs is twice as great as at neaps, so that $P_S = 4\ P_N$, the mean output will be $0{\cdot}594\ P_S$, while if $P_S = 8\ P_N$, the mean output will be $0{\cdot}51\ P_S$.

The curve A B C of Fig. 6 represents the output per tide in the case where $P_S = 4\ P_N$, while O D represents the mean output per tide over the cycle.

If p per cent. of that portion of the output of the primary turbines which is stored and reconverted is lost in the process; if q be the fraction of a complete tide during which the primary turbines operate; and if P_M be the mean output into the distribution system from both primary and secondary turbines, in horse-power hours per tide, the amount of this which may be taken directly from the primary turbines, will be equal to q times the mean height of the area O A H K C O', where O F represents P_M. Calling this mean height X, we have

Loss in storage and conversion

$$= \frac{p}{100}\left\{K P_S - q X\right\}$$

Energy into distribution system

$$= K P_S - \frac{p}{100}\left\{K P_S - q X\right\}$$

$$= P_M$$

Very approximately in practice $X = P_M$, in which case

$$P_M = K P_S \left\{\frac{100 - p}{100 - pq}\right\}$$

Thus if $p = 50$ per cent., and if the turbines operate for 5 hours per tide, so that $q = 5 \div 12{\cdot}5 = 0{\cdot}4$:

$$P_M = \left\{\frac{100 - 50}{100 - 20}\right\} K P_S = .625\, K P_S,$$

as compared with the value $0{\cdot}50\ K P_S$, which would hold if all the output of the primary turbines were utilised in pumping into the storage reservoir.

If $P_S = 4\ P_M$, so that $K = 0{\cdot}594$, the value of P_M becomes $0{\cdot}371\ P_S$, or $1{\cdot}48\ P_M$.

With a system of operation involving a 10-hour working period per tide, P_M would equal $0{\cdot}835\ K P_S$, a value 66 per cent. greater than would be obtained if all the output of the primary turbines were utilised for storage.

(To be continued.)

The Institution of Automobile Engineers.—At a meeting of this Institution on Wednesday last a paper was read by Colonel R. E. B. Crompton, C.B., entitled "Roads and Vehicle Maintenance." In this paper Colonel Crompton pointed out that the damage to the roads was due to impact, and that it was the blows received which forced the material apart and caused deformation of the surface. The necessity for the provision of strong kerbs and haunches was enlarged upon, these being coupled with sunken centre kerbs. Such roads would be free from serious lateral spreading, and this would prevent valleys being formed which would accumulate water. Following up this, Colonel Crompton reviewed the subject from the vehicle point of view and quoted a formula for impact. He touched upon the method now being tried in the United States of investigating this problem by means of the cinematograph, and suggested further research should be conducted in this country by the Society of Motor Manufacturers and Traders and the Ministry of Transport.

The Northampton Polytechnic Institute.—On Friday evening last the prizes and certificates gained by students at the Northampton Polytechnic Institute were presented by Dr. S. Russell Wells, the Vice-Chancellor of the University of London, and on the following evening the members and students held their annual conversazione. On both occasions the workshops and laboratories of the Institute were open for the inspection of visitors, the machinery being shown in operation, and a good display of students' work was made. It will be remembered that the Northampton Institute provides instruction in watch and clock making and repairing, and in physiological and technical optics, in addition to the subjects which form the normal curricula at similar institutions; the work of these departments naturally attracted particular attention on account of its comparative rarity, as well as of the high standard reached. The mechanical, engineering and electrical laboratories and workshops of the Institute, however, are well equipped and ample evidence was available that the work carried on in them is distinctly above the average.

The Dielectric Constant of Silk.—Though silk is largely used as an insulating material, figures as to its dielectric strength are not usually given in tables of constants. When two dielectrics are electrified by contact, the one having the larger constant generally becomes electropositive. If this should hold true for silk, its dielectric constant should be rather large. This is confirmed by experiments made by F. J. Rogers in Stanford University, California, recently described before the American Physical Society. The method Rogers used was the usual condenser method. The difficulty was, however, that silk is not produced as a continuous solid. Rogers, therefore, determined the density of the silk (by weighing in air and in water) and computed the ratio of silk to air in the space between the condenser plates by weight and volume measurements; he also dipped the silk in molten paraffin so as to obtain plates of paraffined silk. The density of the silk (white silk, white and black satin) used was about 1·51, and the dielectric constants, determined with the aid of a bridge, a quadrant electrometer and currents of 60 cycles, ranged from 4·62 up to 5·07. The values are higher than those of some substances: Ebonite 2·8, rubber 2·2, shellac 3·5, quartz 4·5, sulphur about 4, rosin about 2, wax 2·3, paper 2·5, oil 4·7, but lower than the dielectric strengths of glass 6 to 10, marble 8·3, porcelain 4 to 7 and selenium 6, and much lower than those of some liquids, *e.g.*, methyl alcohol 35, and water 81 for very long waves, and also of solid ice 94. But the constants vary greatly increasing with the wave-length.

MACHINERY AT THE SMITHFIELD SHOW.

The annual Christmas cattle show at the Royal Agricultural Hall, Islington, was for many years noted quite as much for the elaborate display of agricultural machinery and implements as for the exhibition of animals in whose interests it was first established more than a hundred and twenty years ago. The Smithfield Club, however, under whose auspices the show is held, remain true to their original object, namely, the encouragement of the edible animal industry, and their prizes and awards, amounting this year to about £4,600, are confined entirely to the exhibitors of meat producing creatures. Machinery appears to be admitted on sufferance only, as a side show, yet the concourse of agriculturists which the show attracts and the facilities which a metropolitan exhibition offers for business, are apparently sufficient inducements for the manufacturers of agricultural machinery to take every inch of space which can be allotted to them. In fact, one would judge the aggregate area devoted to machinery, implements, &c., to be larger than that occupied by the animals; the value is certainly greater, and there can be no question as to the greater durability of the mechanical products, especially in view of the season of the year.

Reviewing the machinery exhibits as a whole, there appears little that is particularly new or indicative of any special evolution in practice. As regards prime movers, the small internal-combustion engine has quite driven steam from the field, except in so far as traction engines, road tractors and steam wagons are concerned. It is significant that we did not notice a single steam boiler at the show, except such as form a structural part of the vehicles mentioned, and the stationary steam engine was represented only by a single specimen, this being a simple vertical engine on the stand of Messrs. Richard Garrett and Sons, Limited, of Leiston. The portable steam engine, which used to be the standard prime mover of the farmer, seems to have vanished utterly as an exhibit, no doubt supplanted by the much more generally useful and convenient internal-combustion motor. Windmills seem also to have been practically ousted by the small motor, although two manufacturers show them, namely, Messrs. John Wallis Titt and Co., of Warminster, Wilts, and Messrs. John S. Millar and Son, Annan, Dumfries.

Steam traction engines, road tractors and steam wagons are shown in great variety, all the leading makers being represented. The workmanship of these machines in this country has always been maintained at a very high standard, but the finish which has been given to those at the Agricultural Hall is alone worth a visit to the show to see. As all are so good it seems invidious to select any one firm for special mention in this respect, but we may say that nothing could exceed the appearance of a traction engine shown by Messrs. Ruston and Hornsby, Limited, of Lincoln. The absolute flatness of its polished surfaces and the perfection of the curves were a credit to the mechanics who produced them. Good polishing is not a matter of shininess alone, and no buffing wheel can approach skilled hand work when appearance is in question.

A compound steam tractor on the stand of Messrs. Marshall, Sons and Co., Limited, of Gainsborough, illustrated in Fig. 1, page 781, has a boiler pressure of 200 lb., the boiler being fitted again with the firm's special fire-box. The cylinders are 4¼ in. and 8 in. by 9 in. stroke. The valve mechanism is of the radial gear type, requiring only one eccentric to the high and low-pressure sides. A three-shaft transmission with machine-cut gears, except for the last motion, is used, the gears running in an oil bath. The road speeds are 2½ m.p.h. and 5 m.p.h., and if used for driving machinery the machine will develop economically 20 brake horse-power. Lubrication of the cylinders is by the firm's latest pattern of oil pumps. The engine is mounted on outside laminated springs. The rear wheels are fitted with a powerful brake acting on the inside of the rims. A winding drum for wire rope is fitted, and a swivel pulley allows the cable

to be used over a considerable range of direction without altering the position of the engine.

Other firms showing traction engines or steam wagons are Messrs. Aveling and Porter, Limited, Rochester; Chas. Burrell and Sons, Limited, Thetford; Clayton and Shuttleworth, Limited, Lincoln; Fodens, Limited, Sandbach; William Foster and Co., Limited, Lincoln; John Fowler and Co., Limited, Leeds; Richard Garrett and Sons, Limited, Leiston; J. and H. McLaren, Leeds; Ransomes, Sims and Jefferies, Limited, Ipswich; Robey and Co., Limited, Lincoln; Wallis and Stevens, Limited, Basingstoke; and W. Tasker and Sons, Limited, Andover.

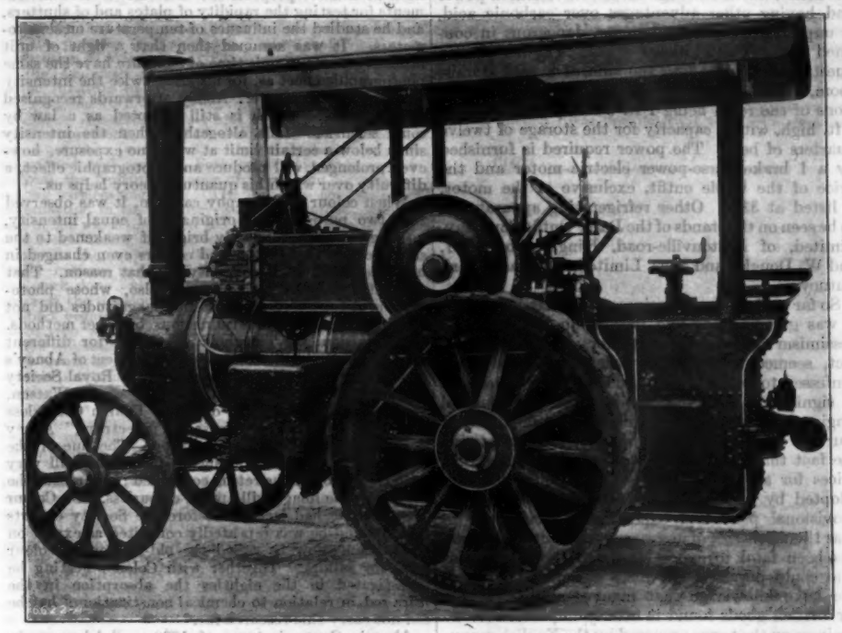


FIG. 1. 5-TON COMPOUND STEAM TRACTOR; MESSRS. MARSHALL, SONS AND CO., LTD., GAINSBOROUGH.

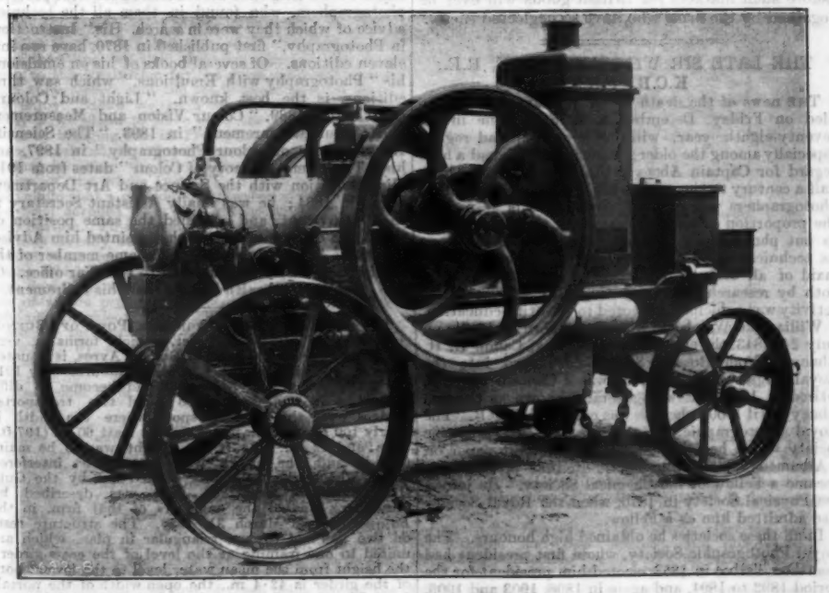


FIG. 2. 16-B.H.P. PORTABLE TWO-CYCLE OIL ENGINE; MESSRS. MARSHALL, SONS AND CO., LTD., GAINSBOROUGH.

Coming to internal combustion engines, of which there is an enormous variety displayed, we may remark that not a single example of a gas-producer appears to be shown. The small suction gas plant seems to have had to give way to the petrol or paraffin engine, and for larger powers the two-cycle heavy oil engine, or the solid injection engine appears to be preferred. The extreme cheapness of the producer gas engine as regards fuel is apparently more than counterbalanced by the attention the plant requires. Vertical two-stroke heavy oil engines are shown by Messrs. Robey and Co., Limited, of Lincoln, and Petters, Limited, of Yeovil. The engines of the latter firm are noticeable on account of a device for injecting a small quantity of oil into the cylinder at the end of the suction stroke, which is just sufficient to maintain the heat of the hot bulb when the engine is running light. Hence it can pick up its load immediately at any time, a feature in which many engines of the kind are defective. Messrs. Robey's heavy oil engine of 20 brake horse-power is an excellent piece of work, but it follows along standard lines and is too well known to need extended reference. Messrs. Petter also show a small two-cycle vertical engine with an attachment for making it suitable for running on town gas, as well as on liquid fuel. This consists merely of an automatic valve admitting the gas to the crank chamber, the gas being controlled on its way by a valve operated by the governor.

Messrs. Marshall, Sons and Co., Limited, of Gainsborough, show a 16 brake horse-power portable oil engine, which we illustrate in Fig. 2, annexed. The engine is on the two-stroke cycle, using a lamp for starting, but fitted with a hot bulb which effects the ignition when running. The engine, we are informed, will use refined, crude or residual oil, up to 0·92 specific gravity. If required for heavier oils than this a preheating apparatus can be fitted, but oils of 0·85 to 0·9 specific gravity, and of a value of about 19,000 British thermal units per pound give the best results. The engine is governed by a shaft governor which, acting through double eccentrics, changes the stroke of the fuel pump according to the load. The fuel sprayer is very simple, requiring no packing. No water injection is necessary under any conditions of working. The engine will run light without a lamp and without special adjustment.

The small hopper type horizontal engine, to run on petrol or paraffin, is largely in evidence. Many American engines of this kind have had a large sale in this country, but it is satisfactory to note that several British firms have at last turned their attention to the type and are now supplying engines of vastly better workmanship at competitive prices. Some of the imported engines are dreadful rubbish, and it is a wonder they run at all without shaking themselves to pieces. The Wolseley Sheep Shearing Machine Company, Limited, of Alma-street, Birmingham, are showing a very nicely finished engine, with H.T. magneto, two flywheels and throttling governor. It is rated at 3 brake horse-power at 600 revolutions and is listed at 50*l*. Another particularly nicely designed and well finished machine of the type is exhibited by Messrs. Crossley Bros., Limited, Manchester. Messrs. Powell Bros., Limited, of Wrexham, are building the type in 3 h.p. and 5 h.p. sizes. The latter, with a 5½ in. by 7 in. cylinder, runs at 500 r.p.m. and weighs complete with pulley and pair of flywheels, 1,200 lbs. It is listed at 75*l*. Messrs. E. H. Benthall and Co., Limited, of Malden, Essex, also deserve mention in connection with the development of this type but very many other firms are putting them on the market. Messrs. Blackstone and Co., Limited, of Stamford, show a large selection of their well-known horizontal oil engines, including their latest type, which starts at once from cold on paraffin, without either the use of a blowlamp or a preliminary run on petrol.

Agricultural tractors, driven by internal combustion engines are, as might be expected, very well represented at the show. We did not notice a single example of the chain track tractor, and it would appear as if tractor design was settling down along more or less conventional lines at any rate in so far as the main outlines of these machines are concerned. The recent tractor trials at Lincoln add a special interest to the tractor exhibits, and most of the machines now shown were illustrated in our account of those trials, in our issues of October 1, 8 and 15 last. The J. S. Case Thrashing Machine Company, of 9a, Stanford Parade, Norbury, S.W., show the type of tractor which was awarded the gold medal for the two furrow class at Lincoln, and the British Wallis, manufactured by Messrs. Ruston and Hornsby, Limited, of Lincoln, and the Peterborough tractor built by Messrs. Peter Brotherhood, Limited, of Peterborough, which also respectively gained the first and second honours in the much-contested three-furrow class at the Lincoln trials, are on view. The Austin tractor, manufactured by the Austin Motor Company, Limited, of Northfield, Birmingham, has been favourably mentioned in these columns on previous occasions for its workmanlike design, but there really does not appear very much to choose between the products of any of the firms who have established themselves in this branch of the industry. Besides the makers we have mentioned, others exhibiting tractors of more or less standard design

are the British Motor Trading Corporation, of 50, Pall Mall, London, S.W.; Henry Garner, Limited, Moseley Motor Works, Birmingham; the International Harvester Company, 80, Finsbury Pavement, E.C.; Noyes, Stockwell and Co., Lennox House, Norfolk-street, Strand, W.C.; Saunderson Tractor and Implement Company, Limited, Bedford; Coenraad de Waal, 2, Great Winchester-street, E.C.; the Associated Manufacturers Company, 124–127, Minories, E.1; Fairbanks, Morse and Co., 87, Southwark-street, S.E.1; Armstrong, Melchior and Dessau, Limited, Great Marlborough-street, W.1; the Martin Cultivator Company, Limited, Stamford, and possibly others.

Certain manufacturers appear to anticipate a demand for tractors of less capacity than possessed by the usual three-furrow type, and Messrs. John Fowler and Co., Ltd., of Leeds, show a two-furrow motor plough in which the machine is more or less balanced about a single driving wheel, the engine being well forward and the ploughs of course behind. This principle is carried still further by the Maskell Motor Plough Company, of Advance Works, Jews Row, Wandsworth. The Maskell plough makes only a single furrow and has a twin air-cooled V-type engine, rated at 10 brake horse-power mounted in front of the single driving wheel. From the engine the first drive is through a pitch chain, giving a slight reduction, and then through two spur-gear reductions to internal teeth on the driving wheel. The machine, which measures 11 ft. overall and weighs about half a ton, is said to be capable of doing double the work of an ordinary two-horse plough. It appears particularly easy to turn or otherwise manipulate, and a pulley is fitted so that the engine power can be used to drive stationary machinery. The complete outfit is listed at 175*l*. The New Britain tractor, shown by Markt and Co., Limited, of 98, Clerkenwell-road, London, E.C., is interesting to engineers as being the production of the New Britain Automatic Machine Company, of Connecticut. It is a very small machine with two driving wheels and two swivelling trailers, and will pull either a single furrow plough or anything of equivalent resistance. The two-cylinder engine is rated at 6 brake horse-power.

The other end of the scale, as regards the application of the internal combustion engine to ploughing is illustrated on the stand of Messrs. John Fowler and Co., Limited, of Leeds. This firm, who for so many years have specialised in cable ploughing machinery have now developed a motor windlass as an alternative to their steam winding traction engines for use under conditions where suitable fuel or water for steam engines is hard to get. This machine, which is certainly among the most striking exhibits at the show, weighs 8 tons and is fitted with a four-cylinder engine developing 60 brake horse-power at 1,000 revolutions. The cable drum, carrying 500 yards of wire rope, is fixed horizontally underneath and centrally with the body. The engine is spring mounted and the whole design is unusually attractive. The outfit is more costly than the equivalent steam tackle, but it possesses certain advantages which will frequently outweigh the extra initial expense. Another design of motor windlass is to be seen on the stand of Messrs. J. and H. McLaren, Limited, of Leeds. This is also for cable ploughing, but in this case the engine is arranged crosswise with the frame, well to the rear of the front wheels, and the winding drum is fitted vertically at the back of the machine. The cable is led from the drum through a guide pulley under the frame, so that the tension comes on the side of the machine. These two machines were both illustrated in our issue of October 15 last.

Refrigerating machinery of the smaller sizes is fairly represented by such firms as Messrs. John Kirkaldy, Limited, of 101, Leadenhall-street, E.C.3; Ernest West and Benyon, Limited, of 82, Belvedere-road, S.E.1; and Parnall and Sons, Limited, of 27, Summer-row, Birmingham. The Kirkaldy exhibit comprises self-contained machines of ½ ton, 1½ ton and 5 ton capacity and a compressor in part section, to show the internal construction. This, as is usual in these small sets, is of the vertical totally enclosed type, in which the gas passes from the crank chamber into the cylinder through an automatic valve in the top of the piston. The delivery valve is a single steel ball. These little machines will run for months on end with no attention whatever and are very popular with butchers and others who wish to preserve perishable goods. The West Benyon machines are of the open type, and built more on the lines of small steam engines. In both cases they use CO_2 as the working substance. The Parnall set, on the other hand, works with ammonia, which although more economical in power and having other advantages over carbonic acid, is unpleasant and may be even dangerous in confined places if any leakage exists. The machine in question is attached to the side of a cold storage room, insulated with slag wool, the internal dimensions of the room being 7 ft. 6 in. by 5 ft. 6 in. by 7 ft. high, with a capacity for the storage of twelve quarters of beef. The power required is furnished by a 1 brake horse-power electric motor and the price of the whole outfit, exclusive of the motor, is listed at 336*l*. Other refrigerating apparatus is to be seen on the stands of the Dairy Outfit Company, Limited, of Pentonville-road, King's Cross, N.1, and W. Douglas and Sons, Limited, Douglas Wharf, Putney.

So far as the general business outlook is concerned, it was gratifying to find nothing in the nature of pessimism amongst the exhibitors. Most firms, in fact, seemed to have full order books and some confessed to being behind-hand with deliveries. It is significant that the Agricultural and General Engineers' Association, which is a combination of fourteen large East Anglian firms, are advertising the fact that they are now prepared to quote firm prices for all their products. The policy hitherto adopted by so many manufacturers, of quoting a provisional price and expecting the customer to bear the whole risk of increased manufacturing costs, has been fatal to export trade to those countries who could purchase anywhere except in England. We have knowledge that many Canadian agents for British goods found it utterly impossible to do business on the terms proposed by the English manufacturers, and are now devoting their energies to the sale of American products. It will be a long time before such markets for British goods will ever be regained by the firms who have so neglected them.

THE LATE SIR WILLIAM ABNEY, R.E., K.C.B., F.R.S.

The news of the death of Sir William Abney, who died on Friday, December 3, at Folkestone in his seventy-eighth year, will cause widespread regret, especially among the older generation, which had a high regard for Captain Abney. His name takes us back half a century to times when the proportion of amateur photographers was as small, perhaps, as is at present the proportion of non-photographers, and he did much to put photography on a scientific basis, to improve its technics, and to make it the indispensable handmaid of all branches of science. That he achieved both by research and by writing. In later years his activity was principally devoted to scientific education.

William de Wiveleslie Abney was born in Derby on July 24, 1843, the eldest son of the Rev. Canon E. H. Abney. From Rossall School he passed into the Royal Engineers in 1861; he was a Captain by 1873, retired in 1881, but was generally known as Captain Abney until 1900, when he was created a K.C.B. The Royal Photographic Society was the first scientific society which he joined, in 1870; his first paper on "Albumen" dates from 1871. In that year he also became a Fellow of the Chemical Society. He joined the Physical Society in 1876, when the Royal Society also admitted him as a Fellow.

In all these societies he obtained high honours. The Royal Photographic Society, whose first president had been Fox Talbot in 1853, elected him president for the period 1892 to 1894, and again in 1896, 1903 and 1905. He was thus president at the Jubilee meeting of the society in May, 1903. He was on the council of the Chemical Society in 1882 to 1884, was president of the Physical Society in 1895 to 1897, and was awarded the Rumford medal of the Royal Society in 1882. The Royal Astronomical Society elected him president in 1893 and the Royal Society of Arts elected him as Chairman of Council in 1903.

The work of Sir William Abney was almost all connected with light, vision, photometry, spectroscopy, and with photography in particular, while the physical aspect of the phenomena attracted him more than the chemical side, though the chemical problems naturally claimed his chief attention in the seventies when the dry plate was replacing the wet plate. Much original research had to be conducted before the amateur could be supplied with the handy dry plate which popularised the camera. Alkaline developers, essential for the dry plate, had been used by C. Russell in 1862. But the ferrous developers of Eder and of Abney, and Abney's hydroquinone, were new, and as early as 1874 Abney had first attempted to effect quantitative light measurements with the aid of his diaphanometer (wedges), which he later combined with rotating sectors for decreasing the intensity of a light in definite proportions. He also devised instruments for testing the rapidity of plates and of shutters, and he studied the influence of temperature on sensitometers. It was assumed then that a light of unit intensity would in unit time of exposure have the same photographic effect as, for instance, twice the intensity with half the exposure. Abney afterwards recognised that this rule—which is still accepted as a law by some scientists—fails altogether when the intensity sinks below a certain limit at which no exposure, however prolonged, will produce any photographic effect, a difficulty over which his quantum theory helps us.

When colour photography came in, it was observed that two pure colours, originally of equal intensity, no longer appeared equally bright if weakened to the same degree, and that mixed colours even changed in hue when reduced in intensity for that reason. That difficulty troubled astronomers also, whose photographic determinations of stellar magnitudes did not always accord with determinations by other methods. Colour vision, the Threshold of Colour for different Lights, and Night Blindness were the subject of Abney's latest communications presented to the Royal Society partly in conjunction with the late Professor W. Watson. In his last paper of 1916 on the "Fourth Colourless Sensation in the Three-Sensation Spectrum," Abney dealt with the following problems:—The hue of the image of a small disc falling on the retina will vary with the region of the retina concerned; when near the periphery the image will appear colourless. On Colour Blindness he had lectured before the Society of Arts in 1892, and he was repeatedly consulted as expert on —what must now be called the old-fashioned—colour tests for sailors. Together with Colonel Festing he investigated in the eighties the absorption in the infra red in relation to chemical constitution; but he did not carry this research far.

Abney's Cantor lectures of 1882 on "Advances in Photography," his lectures on "Photography and the Spectroscope," and his many popular handbooks remained for a long time the standard guides for practical photographers, who found in them all the technical advice of which they were in search. His "Instructions in Photography," first published in 1870, have run into eleven editions. Of several books of his on emulsions, his "Photography with Emulsions," which saw three editions, is the best known. "Light and Colour," came out in 1889, "Colour Vision and Measurement and Colour Measurement" in 1893, "The Scientific Requirements of Colour Photography" in 1897, and his "Trichromate Theory of Colour" dates from 1914. His connection with the Science and Art Department began in 1884; he was finally Assistant Secretary to the Department, and occupied the same position on the Board of Education, which appointed him Adviser in 1903. At the same time he became member of the Advisory Council for Education to the War office. Of late years failing health had enforced his retirement.

Transporter Bridges for the Port of Buenos Ayres.—The Riachuelo inlet, which forms a very important part of the port of Buenos Ayres, is situated between the city and the Avellaneda suburb. By 1917 the traffic across the Riachuelo had become so difficult that it was decided to build two transporter bridges over the river at spots where the width is nearly 100 m. A clear water-way at least 60 m. (197 ft.) wide and 42 m. (138 ft.) in height was to be maintained, and the quays were not to be interfered with. The work was finally carried out by the Gute Hoffnungshütte, Sterkrade, and was described by Kusenberg, one of the engineers of that firm, in the *Bauingenieur* of March 31, 1920. The structure rests on two pairs of towers, triangular in plan, which are united to one framing at the level of the cross-girder; the height from the mean water level to the lower boom of the girder is 42·4 m., the open width of the portal, formed by the two towers of a pair, is 24 m. (79 ft.), and the span across the river 67·6 m. (222 ft.). On the track below the main girder runs a trolley truck. The 12 steel ropes extending from the trolley down to the suspended platform are 29 mm. (1·14 in.) in diameter and are adjustable in length; temperature fluctuations of ± 35 deg. C. (63 deg. F.) were allowed for in the design of the structure. The platform takes a tramway car, room being left for a footway on either side. The suspended load may amount to 45 tons. The structure, almost entirely of mild steel, weighs 499 tons. The water-way had, of course, to be kept unobstructed during construction. The four towers rest on four points, two of which, one on each side of the river, are fixed, whilst the other two, also fixed as to their length, measured across the river, can slide at right angles to that direction. The bases of the towers with their pile foundations extend some distance back into the shore, back anchoring not being admissible.

WIRELESS TELEGRAPHY AND TELEPHONY DURING THE WAR.*

By W. H. ECCLES, Chairman of the Section.

I PROPOSE to devote the main part of this address to a review of the work done by the Wireless Section of the Institution of Electrical Engineers in putting on record the development during the war of the practice and theory of wireless telegraphy and telephony, but first of all I think this occasion offers a suitable opportunity for saying a few words concerning the formation of the Section. Many of the members present will remember that in the year 1916 a movement was started for the purpose of founding a professional Society or Institution of Wireless Engineers somewhat on the lines of the American Institute of Radio Engineers. This latter Institute had already scored a great success in the valuable work of bringing together many of the best minds in America for the oral and written debate of wireless problems, and had established and conducted an admirable journal. The Institute had obviously stimulated and assisted, both by its meetings and its journal, the fruitful exchange of views and information among wireless engineers. The lack of a corresponding organisation in this country was very marked, and the end of the war emphasised the deficiency. The progress of wireless during the war was so great that all existing books on the subject in this country were out of date. Other nations were beginning to publish accounts of the work done by their signalling services and, indeed, some of the developments and discoveries made in this country began to appear in foreign journals. Meanwhile those who were considering the possibility of forming a new professional Institution of Wireless Telegraphy were confronted by an array of financial difficulties. At this juncture, Mr. Wordingham, then President of the Institution of Electrical Engineers, ever on the look-out for chances of doing good deeds, suggested that the Institution should form a Wireless Section for obtaining, reading and discussing papers which might afterwards be printed in the Institution journal. Thereupon the fears which I have just mentioned—printers' and publishers' bills, rent of premises, salaries of staff, &c.—disappeared. The chief flaw in the proposal appeared to consist in the fact that the papers read before the Wireless Section would be mixed up in the journal with papers on heavy current engineering and would therefore be less easily referred to in the bound volumes, but this did not weigh greatly with those who had heard that a new wireless journal was being planned wherein all the specialised matter that every student of wireless wishes to keep together for reference would be concentrated. I speak of the *Radio Review*, which has since made such a splendid position for itself under the able guidance of Professor Howe and Mr. Coursey. In addition, I think I may say that the Institution will probably shortly see its way to arranging its journal so that the wireless portion can be bound separately by those members who so desire.

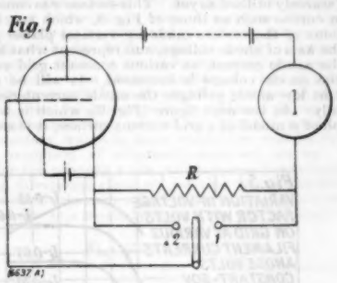
I think that the Wireless Section will not feel satisfied unless they can see that they are able to give some return to the Institution for the great material benefits which they receive and the ready-made prestige which they enjoy. Shall we as a Section flatter ourselves unduly if we claim to have done the Institution some service by bringing into its Proceedings many important papers which might otherwise never have reached it, and that in other the Section has contributed to the prestige of the whole Institution? We can, I think, safely claim that a considerable number of new members have been enrolled as a consequence of the formation of the Section. Thus the step initiated by Mr. Wordingham may already be said to have been amply justified. Much of the success is due to the strong and unfailing backing which the section has received from Mr. Roger Smith during his term of office as president; that happy state of affairs promises to continue during the reign of the new president, Mr. Atkinson.

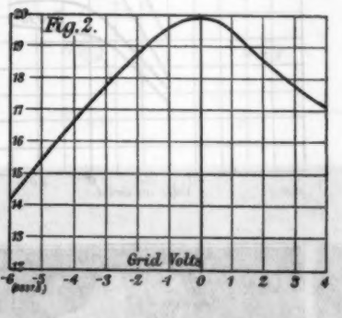
That the formation of the Wireless Section has been appreciated by all those interested in wireless communication can be seen from the records of attendance at the meetings. The number of persons who had signed the attendance book was 1,297, the average attendance being 130.

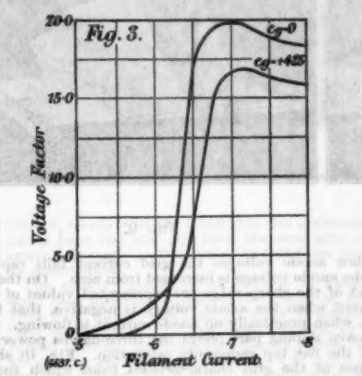
Two lectures and eight papers have been given. I believe that some of these papers might never have been written had it not been for the persuasion directed upon the authors by the committee of the Section. These papers have all been of such a high order of merit that the Council of the Institution have been—if I may tell such secrets—greatly embarrassed in distributing the prizes or premiums awarded to the authors of papers of outstanding merit. In this matter of premiums the Institution has been most generous, and the Council decided to give three premiums to papers read before the Wireless Section, the first of these being named the Duddell premium, of value 20*l.*; the others are of value 10*l.* each. An extra premium was given last session. The Council have also drawn up during the past session rules for the government of the Section and the election of its committee, thereby giving it a very generous measure of autonomy.

During the past session the committee of the Section have endeavoured to secure that the principal advances made in wireless communication during the war should be described by the men who played so large a part in making them. From the material thus collected I propose to make a sort of stocktaking—to set forth briefly some of the more striking improvements achieved.

In 1913 the musical spark method of transmission was still in use at some of the largest stations in the world; the arc, the timed spark, and various forms of alternator with and without frequency changes, were, however, formidable rivals. Signals from spark stations were received by crystal detectors or by Fleming valves, or by audions with two electrodes; continuous-wave signals by the ticker and its cousin the tone wheel. The continuous-wave circuits of those days did not show outstanding advantages over spark circuits. It is true that the heterodyne system of reception—in which the received signal is combined with a local oscillation of almost the same frequency so that the relative motion of two currents is observed—had been introduced by Fessenden long before 1913, and that he had used arcs and alternators at the receiving stations for generating the oscillations destined to beat with the incoming signal oscillations; but this heterodyne method was cumbersome in practice and lacked many of the features which have made the modern methods so successful. It is again true that De Forest's audion with three electrodes and the Lieben Reisz vacuum tube were also becoming







known, but both of these tubes were used as amplifiers, singly or in cascade, and they were equally useful with both spark and arc signals. Certainly at this date there seemed no imminent likelihood of continuous-wave telegraphy completely ousting the spark in long-range work.

But during the year 1913, directly after the art of amplification had been grasped, the possibility of generating oscillations even of very high frequency was seen, and then the heterodyne method of reception of signals sprang on to a different plane. For this method of generating feeble oscillations for combining with the signal oscillations was so simple, perfect and manageable that it realised the highest ideals of the wireless engineers. But this is not all, the three-electrode vacuum tube oscillator magnifies the signals while it generates the oscillations. For the oscillator must of necessity possess positive retroaction between the anode and the grid circuits, that is the back coupling from the anode to the grid is such that any electrical movement in the anode circuit produces one in the grid circuit, so that the original movement is reinforced and therefore any stimulus applied in the circuits is magnified. In achieving this the three-electrode tube did not lose the rectifying property of the Fleming valve. It retained this unimpaired or, indeed, in an enhanced degree. Now rectification is necessary before the beats produced by the combination of the received and local oscillations can give an audible effect in a telephone receiver. It was thus found possible in 1913 (by Captain Round, in this country) to generate local oscillations, to magnify the received signals and to rectify the combined result, all with one tube, which process is often called the autodyne method of reception. This happy combination of qualities was so especially favourable to continuous-wave wireless telegraphy that this received an immense impetus over the spark method for long-distance work.

Such was the situation in this country at the beginning of the war. Of the progress made since that date we can find a fairly complete chronicle in the lectures and papers read before this Section. It will be found that progress has not been so great with regard to the transmitting plant as with regard to the apparatus for reception, though a paper by Mr. M. Latour has given us a glimpse of recent developments regarding some of the alternators being installed in long-range stations.

As regards progress in methods and apparatus for reception and in small transmitting sets, we obtained a very perfect account from Colonel Cusens, who dealt with designs evolved for use in the Army, and from Major Erskine Murray, who dealt with the designs of the Air Force. In addition to these, Major Prince dealt with wireless telephony on aeroplanes and Captain Eckersley with duplex wireless telephony. A complete theoretical and practical account of amplifiers as developed for use in the Navy was given by Professor Fortescue, and that remarkable instrument the oscillatory valve relay was described by its inventor, Captain L. B. Turner. All these papers may be regarded as records of finished achievements complete in themselves, but certain of the other papers were in the nature of unfinished symphonies, and these I shall refer to shortly.

On the whole the outstanding feature of this development is the three-electrode thermionic tube sometimes called the pliotron or the audion, or the three-electrode valve, but which I call a triode in order to avoid offending these other people. This instrument is in somewhat the same stage of development as the dynamo electric machine was forty or fifty years ago. Then, as now, in order that it may be developed to the limit of its possibilities its characteristics must be studied, endless measurements must be taken, and its theory built up. As in the case of the dynamo and motor theory and practice must proceed together, and we may almost say "useless each without the other." The design of these tubes for reception and many of their properties, were discussed in a paper by Mr. B. S. Gossling, and valuable data concerning the filaments were communicated to the Journal of the Institution by Mr. Stead. Mr. Gossling's paper covered an immense range dealing with several years' work in the Service laboratories. I do not propose to say anything in the way of repetition, but should like to call attention to some of the inquiries provoked.

I may put first certain results not yet fully discussed which arise in the use of these tubes, even in respect of such a fundamental parameter as the voltage factor. The voltage factor is the ratio of the free electromotive force appearing in the anode circuit in response to that which is applied in the grid circuit. In certain modes of using the tube, for instance, in the tubes occurring in the later stages of a many-stage amplifier, the value of the voltage factor realised is disappointing with certain adjustments. I have had measurements made during the past year or two by various students, on many tubes, in which a rather large change of voltage was applied to the grid. The method of measurement is a very simple and handy one when these conditions are permissible.

In Fig. 1 the anode is connected in series with a battery E, an instrument I, a resistance R, and the filament. The grid is connected to a switch through any battery, as may be desired (not shown in the figure). The resistance R is preferably of dial pattern. The operations consist first in giving R any convenient value, say R_1 and putting the grid circuit switch on the point marked 1, and second in moving the switch to 2, while adjusting the resistance to bring the anode current to its previous value. Let this second value of the resistance be R_2, then the voltage factor is

$$(R_2 - R_1) / R_1.$$

For quick measurement it is very convenient to make R = 1,000, then the final reading of the resistance box minus 1,000 gives the voltage factor by the movement of a decimal point.

The same apparatus can be applied to the measurement of the internal resistance of the triode by keeping the switch on the point marked 2. The operations consist in observing the current when R = 0 and, second, in observing the changed value of the current when R is any convenient value. If S be the resistance of the shunt galvanometer and i_1 and i_2 the observed currents, then the internal resistance of the tube is

$$\frac{R\, i_2}{i_1 - i_2} - S.$$

A quick way of using this method is to read i_1, take ten elevenths and adjust the resistance to bring the current reading to this value, then the internal resistance is 10 times the figure given by the resistance box.

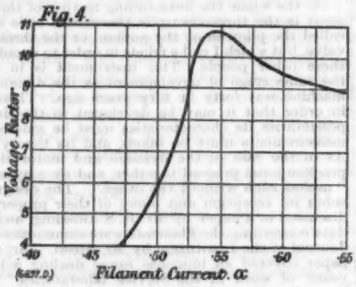
The results of measurements made by this method are shown in Fig. 2, in which the ordinates give the voltage factor and the abscisse are the voltage of the battery permanently connected in the grid circuit, the filament current being constant.

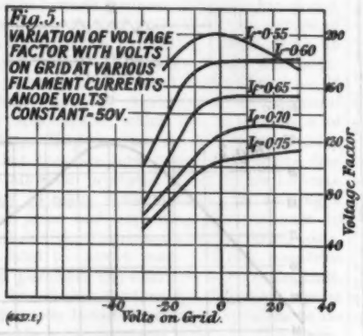
Another set of results showing how the voltage factor varies with the filament current is given in Fig. 3, and for an entirely different tube in Fig. 4. These measurements have been made by the following students at Finsbury Technical College, Messrs. C. W. Cosgrove, C. A. Wilck, J. L. Hewitt, W. Gwynne, R. L. Dawson, E. M. Walden. An interesting series of curves appears in Fig. 5, the abscissæ being the volts on the grid and the ordinates the voltage factor. The filament current is constant

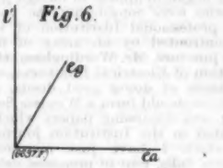
* Address delivered to the Wireless Section of the Institution of Electrical Engineers on November 17, 1920.

on each curve. These curves were made by Messrs. Everitt and Newman. It will be seen that the voltage factor undergoes great variation when these tubes are used for magnifying rather larger changes of voltage than are applied to them in the bulk of wireless telegraph experiments. The reason for the variation of the voltage factor arises out of the unevenness of the temperature of the filament to some extent, but chiefly out of the drop of voltage along the filament. For instance, if the grid be connected to the negative terminal of the filament the grid is 5 volts below the positive end of the filament in potential. Therefore, when a rather large negative voltage of, say, 2 volts to 4 volts is applied in making the measurements, or in actual use, this end may be put out of action, with consequent lowering of the average voltage factor utilised. Again, if the filament current be increased the difference of potential between the grid and the positive end of the filament also increases, with the result that the average voltage factor may again be lowered. Further, if the filament current be considerably reduced the ends of the filament may become saturated and the effective voltage factor again reduced. I am calling attention to these matters because they lead to apparent anomalies in the behaviour of triodes applied to other purposes than the reception of faint wireless signals.

Variation of the average value of the voltage factor as the filament current is altered (as shown in Figs. 3 and 4) bears a striking likeness to the curves depicting







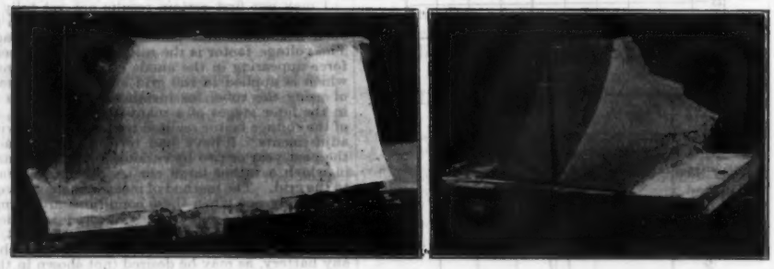


FIG. 7.

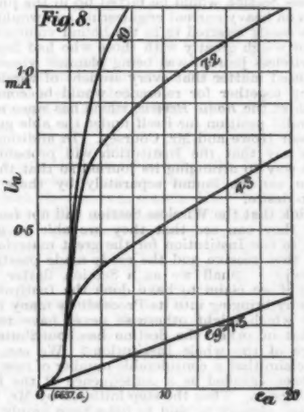


FIG. 9.

Fig. 6 shows three lines at right angles, the horizontal line marked e_a is the axis of anode voltage, that marked e_g is also horizontal, and is drawn perpendicularly through the page away from the reader to represent grid voltages. The line marked i is vertical, and is used to represent either grid or anode current. Upon these axes we may erect surfaces to represent the current flowing in a triode at any assigned values of the two voltages by measuring off to scale these voltages along the appropriate axes, and erecting at the point determined a vertical with two ordinates equal in value to the observed currents. When this is done we obtain for the anode current such a surface as is shown in the photograph of Fig. 7. The flat top represents the saturation values, the concave sloping surface at the right hand side follows in the ideal case the three-halves power law, and normally only a small part of this area on the extreme right hand of the picture is utilised. On the left hand, where the surface descends in a kind of cliff to the axis of the grid voltage, we have a region little investigated and scarcely utilised as yet. This surface was constructed from curves such as those of Fig. 8, which are, in fact, sections of the surface made by vertical planes parallel to the axis of anode voltage, and represent what happens to the anode current, at various constant grid voltages, as the anode voltage is increased. It will be noticed that at low anode voltages the anode current rises very rapidly. In the next figure (Fig. 9), which is a photograph of a model of a grid current surface, it is seen that

the results of some measurements made by Dr. Vincent in 1918, on the change of the wave-length of the oscillations generated by a triode under certain conditions. Perhaps the changes usually occurring in the wave-length generated as the filament battery runs down owe their origin to variations in the average value of the voltage factor. By availing oneself of the flat part of the curves the filament current may be set so that the inevitable slight running down of the filament current will for a long time produce no change in the wave-length. This matter of constancy of wave-length will become of growing importance as the world becomes crowded with wireless stations, in fact the crowding of wave-lengths is continually receiving international attention now. Methods of transmitting within very narrow ranges of wave-length may have to be devised, and in consequence receiving antennæ and apparatus with sharp tuning may become essential. There are other reasons for this latter tendency, namely, the fact that sharp tuning and slow losses go together. Important problems will then arise concerning the increased capital expenditure for building low-resistance antennæ and apparatus, and the interest and depreciation will have to be compared with a possible saving of energy and the value of the other advantages of precise tuning. This reminds me that a paper read before the Section by Professor Howe, on the high frequency resistance of wires, has an important bearing on these problems.

Among other insufficiently investigated properties of the triode are those associated with certain portions of the characteristic surfaces which may be used to represent all the principal properties of the tube. When the filament current and voltage are kept constant there remain four principal variables, namely the anode current i_a, the grid current i_g, the anode voltage e_a, the grid voltage e_g. If we represent anode current and grid current separately each of these must be regarded as a function of the two independent variables e_a and e_g. at low anode voltages the grid current falls rapidly, as the anode voltage is increased from zero. On the left hand of the sharp ridge are represented values of grid current when the anode voltage is negative, that is to say, when practically no anode current is flowing. The concave sloping part obeys the three-halves power law and the flat top represents saturation. Fig. 10 shows shapes of the grid characteristics from which such a surface as that of Fig. 9 is prepared. All the familiar characteristics seen in books and papers can be obtained from these surfaces by making sections.

The rapid rise of anode current and accompanying fall of grid current in the region of low anode voltages requires explanation. In Fig. 11 the diagram on the left indicates possible paths of electrons when the grid is slightly positive and the anode at zero voltage, A being the anode, G a grid wire in section, and F the cathode. Electrons starting from the cathode with considerable normal velocity may perform wide orbits round the grid wire, but are finally drawn into it. But if the anode is slightly positive many of the electrons not passing too near the grid wire end their career on the anode. It may be shown that the grid current has the value

$$i_g = A' (e_a + \nu e_g)^{\frac{3}{2}} \exp.\{ - a \sqrt{(e_a/e_g)} \}$$

and that the anode current is given by

$$\log (1 + i_a/i_g) = a \sqrt{(e_a/e_g)}$$

at low voltages, where ν is the voltage factor and A' and a are constants that are different for each tube. For ordinary reception triodes a has the value 1·3 approximately.

These considerations call attention to a fact that does not appear to have received adequate notice, namely, that the grid in a triode may exert two different types of action. The type just described, which is characterised by having the bulk of the grid current contributed by electrons that have suffered great lateral deflections, may be called a snatching action, the other type of action, which is that usually utilised in triodes, is in the nature of an acceleration or deceleration of the motion of the electrons from the cathode to the anode; in brief, one type of action by the grid is mainly a lateral attraction of electrons, the other is mainly a longitudinal effect in the direction of motion. The steep surfaces near the axes of grid voltage in Figs. 7 and 9 are due to the snatching action.

In Fig. 12 is shown a surface representing by its ordinates both the grid and anode currents of an ordinary form of triode. It is seen that the snatching action that goes on between the grid and the anode at low anode voltages produces a gully separating the two surfaces. The question immediately arises: What is there beyond the region embraced by this figure? Very little published information is available for answering this question, but during the past eighteen months I have had parties of students studying the geography of the gully and the plateau seen in Fig. 12. In particular I have to mention the work of Mr. L. Grinstead and Mr. T. W. Price in this connection. As a result, I am able to give in Fig. 13 a photograph of a surface representing most of the properties of ordinary triodes. The gully noticed in the previous figure is seen to take a sharp turn. On the extreme right of the model a section taken at a fixed and fairly high anode voltage is seen, and this section is therefore the characteristic curve of the grid and anode currents as the grid voltage varies. On following the curve of section from front to back the anode current is seen to rise from zero to a maximum as the grid voltage rises, to remain nearly constant till the gully is reached and there to descend suddenly; during this descent the grid current rises and becomes greater than the anode current. The plateau beyond the gully belongs to the grid current. This is not strictly what happens in an ordinary reception triode, but certain types of tube give such a surface with fair exactitude. A form of triode described by Major Erskine Murray gives a characteristic very like that shown by this section of the model.

It should be mentioned that these models relate to somewhat ideal tubes. In actual tubes, for the reasons already stated, the edges seen in the surfaces are rounded off considerably.

Let us now turn to another of the papers read before this Section, which was vastly provocative and stimulating, namely, that by Captain H. J. Round, on "Directive Telegraphy." The perfecting of high-power amplifiers had the important result of making possible the directive reception of distant stations by small antennæ such as simple frames or crossed aerials with the radiogoniometer. For instance, it became possible to receive transatlantic signals in England with a small frame aerial a yard square. The direction of the sending station can be determined by rotating the frame, or the radiogoniometer coil, about a vertical axis until the signal intensity is zero. But it was soon found that false directions were obtained during sunset and sunrise, the errors often ranging over 30 deg. of arc. Throughout the night, too, false directions are given erratically and, moreover, the sharpness of the minimum is often spoiled. This has, of course, disadvantageous consequences in respect of duplex working utilising balanced aerials. Captain P. P. Eckersley has suggested that much of the directional error might arise from the rotation of the plane of polarisation of the signal bearing waves

by reflection at non-level portions of the Heaviside layer between the sending and receiving stations. The whole matter provokes inquiry, if only because the phenomena affords another mode of gaining knowledge about the upper atmosphere. I am going to suggest another reason than that just stated for the production of waves with rotated planes of polarisation, but to show the errors caused by such rotation, however produced, I have here a model of a receiving frame aerial movable about a vertical axis and a ray of electromagnetic radiation incident upon the frame. The ray is represented by a straight rod, and this is fixed at an inclination to the horizontal because it is abundantly proved that rays bending round the globe follow a curved trajectory resembling that of a projectile. For example, Captain Eckersley has shown that a horizontal loop can receive signals. In the daytime these rays have their magnetic forces horizontal. In this model the magnetic force of the wave is represented by a wooden bar fixed perpendicularly to the end of the rod representing the ray; and when the rod is pushed so that its end and the bar touch the frame, this latter assumes the position in which an actual frame aerial must be placed to receive no signals, that is so as to have none of the magnetic force of the waves linking with it. But now suppose that at night the plane of polarisation is rotated in any manner; we mimic that by rotating the rod and its perpendicular bar while keeping both in contact with the vertical frame aerial. It is observed that the frame must rotate also. That is to say the apparent direction of the source of the radiation, namely, the perpendicular to the frame aerial, is erroneous. It is easily seen that if γ is the error, α the inclination of the ray to the horizontal, and β the rotation of the plane of polarisation,

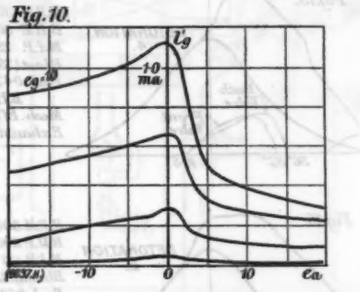
$$\tan \gamma = \sin \alpha \tan \beta.$$

Thus if it be true that the trajectory of the ray always lies in a vertical plane through both stations, the error in azimuth enables us to compute the angle at which the ray descends to the receiving station.

But there still remains the problem of the cause of the rotation of the plane of polarisation. Those who have thought about the behaviour of an ionised atmosphere towards electric waves passing through it will see at once that the earth's magnetic field will introduce obliquity into the motion of ions propelled by the electric force of the waves. Whether the obliquity so introduced can be of appreciable magnitude is decided by an easy calculation. I have made this calculation on the assumption that the waves traversing the upper ionised atmosphere have an electric field of order 1 volt per kilometre. Waves passing over any particular ion evidently impart to it a to and fro' motion of the same period as that of the waves, but lagging behind the electric force of the waves by about a quarter period on account of inertia.

Now the ion when moving in the earth's magnetic field is deflected by that field, and so acquires an oblique component of velocity. The question is what magnitude of magnetic field is required to produce an oblique component of velocity of the same order of magnitude as that produced by the electric force of the waves? On taking the case of an oxygen ion I find that a magnetic field of 1,700 c.g.s. units is required; for a hydrogen atom 100 units, for an electron 0·06 unit. Now the earth's magnetic field at the surface has a horizontal component of about 0·18 unit. Therefore, if I have made no mistake in the arithmetic (I hope I have not omitted the velocity of light from the calculation), we conclude that a rotation such as is demanded by the observed facts of directive wireless telegraphy could be furnished by the passage of the waves through a space containing free electrons.

The next step is to see how this motion of the electrons affects reception. In the first place the setting of the electrons in motion absorbs energy from the waves and, in fact, may extinguish them. But every vibrating electron is itself a small Hertzian oscillator and the accumulated effect of the simultaneous oscillation of a whole cloud of electrons may produce an effect at the receiver—the cloud is, in fact, lighted up by the waves and then the cloud acts as if it were a source. The plane of polarisation of this secondary radiation is the same as that of the motion of the electrons. In these latitudes the vertical electric force of wireless waves will, in conjunction with the earth's magnetic field, cause an electronic vibration in a line descending from the north-east point to the south-west point. Hence the radiation from a cloud of such electrons will arrive at a receiving station due north of the cloud with the magnetic field dipping from west to east, at a station due south with dip also west to east, and at stations due east and due west with dip from south to north. These dipping magnetic fields at the receiving aerial will cause errors of direction, as already explained; and if part of the primary waves from the sending station get through as well, the minimum will be ill-marked—in fact, the simultaneous reception of the primary waves and the secondary waves in time quadrature will be equivalent to reception of elliptically-polarised waves. Leaving aside the primary wave, which does not necessarily cause any directional error, we see that waves travelling from the south through a high layer of free electrons should give rise to a westerly error if the above conclusions are correct, waves from the north give also a westerly error; waves from the east and from the west give southerly errors. It ought to be possible to test these conclusions by observations.



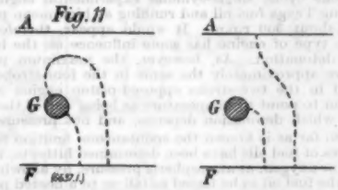


FIG. 12. FIG. 13.

The velocity gained by an electron in waves of the same field intensity is greater the lower the frequency. Thus long waves should give greater directional errors than short waves. It has been recorded by Captain Round that the marking and spacing waves of Horsea arc station have been known to give at night direction readings differing by 30 deg.; but unfortunately it was not recorded whether the result on the longer wave or on the shorter was further from the true direction. Again it is to be remarked that if a station were to transmit a group of slightly differing wave-lengths, a kind of spectrum analysis could be performed by aid of a rotating vertical loop or radio-gonoimeter. Since the imposition of a musical tone upon continuous waves is equivalent mathematically to the introduction of extra frequencies this "spectrum analysis" could possibly yield tonal effects.

The information gained from observations made with directive aerials must be combined with the knowledge furnished by the analysis of the records of magnetic variations and magnetic storms. Professor Chapman read a paper before the Institution setting forth the conclusions he drew from such an analysis. Magnetic storms, he considered, were mainly due to currents in the auroral layers, and these never come lower than about 100 km. Below this is a layer about 50 km. thick in which flow the currents causing much of the diurnal variation of the magnetic elements. The conductivity of this layer is produced by the sun's action, but remains throughout the night. Magneticians do not require any other conducting layers in the atmosphere, and this is in sharp contrast with the requirements of the wireless observer; for the enormous difference between day and night signals absolutely demands diurnal ionisation and de-ionisation of some of the upper layers. Professor Chapman suggested that the auroral layer was conducting chiefly because of the presence of alpha particles that had come from the sun; I think that wireless investigators would suggest that the layer beneath the auroral layer is occupied by electrons that have come as beta rays from the sun. The atmospheric pressure at above 50 km. height is only about a millionth of an atmosphere, the mean free path of the electrons is therefore long, and they may possibly remain permanently free in large numbers.

It would seem that the base of this region charged with free electrons must be regarded as the ceiling usually known as the Heaviside layer. And consequently the diurnal variations of the range of wireless signals must be due to the kind of ionisation of gases familiar in laboratory work with X-rays and the gamma rays from radium.

In fact, I suggest that this diurnally-ionised layer below about 50 km. is ionised by the gamma rays and other ultraviolet rays from the sun and involves the splitting of electrons from molecules to make positive ions; and at the gas pressures in fairly low levels many of the electrons will combine with neutral molecules to form negative ions. Both positive and negative ions of molecular size give rise to ionic refraction and the arched trajectory of the Hertzian rays, and incidentally to absorption also. Professor Watson's solution of the daylight propagation problem takes account at least partially of such a layer of conducting gas, and from his result we may deduce that if the ionisation is effective down to 25 km. the conductivity need not be a quarter as great as that of sea water in order to ensure results such as are summarised in the Austin-Cohen empirical formula.

Dr. Graham Bell, whom we are so glad to welcome here to-night, and who has addressed us so invigoratingly, has told us that this Section of the Institution represents to him the advance guard of the British electrical world. It is noteworthy that wider public interest attaches to wireless telegraphy than to any other branch of electrical engineering. There are, for instance, innumerable amateur societies for the study of wireless telegraphy, but none, so far as I know, for the study of the Wheatstone bridge. What is the reason of this? Is there romance in holding communion with persons and places one may never see, and in receiving messages that have come over the wastes of the globe, or even across the frozen pole? Or does the lure reside in the enormous miscellany of physical phenomena and principles that is called upon to do direct service in wireless transmission and reception? Whatever the fascination is due to, it seems to me to be the expression of a true instinct that in our subject we live nearer the growing edge of electrical science than in other branches of engineering. There is infinite scope for knowledge, discovery, invention and imagination; and I am delighted to know that Dr. Graham Bell is also of that opinion.

And along some of the avenues of our particular technology we may catch glimpses of the radiant expanses of the dawning electrical age. The thermionic vacuum tube in itself contains for the engineer of vision some of the most resplendent of these vistas. For from the glowing filament the most subtle and potent of all the gases is evaporated, namely, the gas made up of pure electrons, a gas we cannot at present harness as easily as steam is harnessed, but which must take its turn as a servant of man. And in those future days strange engines of giant strength, utilising electrostatic forces and thermodynamic cycles as yet unimagined, will be fed with electrons urged by millions of volts along vacuous conduits and will be presided over by matterless switches; and the people of that age will look back and wonder why we in the twilight of the age of steam were so long content to poke slow floods of electricity through the crowded atoms of copper cables.

THE HEATH UNIT HOLLOW BRICK.—In our short account of the Heath hollow brick, given on page 574 *ante*, we gave the sizes of the units which have been adopted in the United States. These are somewhat different from the sizes suitable for British work, and lest there should be any misunderstanding, and the brick be thought unsuited to conditions of work on this side, we now give the sizes adopted for British manufacture. The British full-length double hollow brick measures 9 in. by 6 in. by 13½ in., and the half-length 9 in. by 6 in. by 6¾ in. The single hollow brick, full length, is 4½ in. by 6 in. by 13½ in., and half-length, 6¾ in. The corner and jamb brick is 9 in. by 3 in. by 6 in., and the pier and pilaster unit 9 in. by 4½ in. by 6 in. As already noted the bricks can be made with three dies which can be readily fitted to existing machines.

THE ADDER SHOT-FIRING APPLIANCE.—We are informed that the Adder detonator and safety shot-firing appliance has been granted exemption under the provisions of the Coal Mines Order, which prohibit the removal of any part of the stemming and pulling out of the detonator of miss-fires. The appliance is the invention of Mr. R. D. Harris, of Seven Sisters, Neath, Glam., and is described in the Proceedings of the South Wales Institute of Engineers, vol. xxxv, No. 1, issued July, 1919. The appliance consists of a container tube about ¾ in. in diameter provided with a scoop at the inner end in which the detonator is placed. A rod about ¼ in. in diameter runs down the centre of the tube and acts as an ejector for the detonator. The scooped end of the tube is screwed to take a small cutter or drill which is used for piercing the last cartridge with a hole for the detonator. By means of the ejector the detonator is then pushed into the charge and the container tube withdrawn. If a misfire occurs a special drill borns out the tamping and the detonator may be withdrawn by the leads. The detonator used is specially designed so that when subjected to this pull the only stress comes on to a lead plug and shellac, thus ensuring safety in withdrawal.

FUEL OIL IN DIESEL ENGINES.

*Some Experiments in Connection with the Injection and Combustion of Fuel Oil in Diesel Engines.**

By Engineer-Commander C. J. HAWKES, R.N.(Ret.), (Member), Professor of Engineering, Armstrong College, Newcastle-upon-Tyne.

(*Concluded from page 752.*)

In nearly all engines of the opposed-piston type which the author has seen running the injection of the fuel oil has been accompanied by slight detonation. These engines, however, did not run much above 200 r.p.m., whereas the experimental opposed-piston engine, referred to in this paper, was run at speeds up to 360 r.p.m. In certain circumstances the detonation of the fuel in the experimental engine was most marked, and although it did not appear to be harmful it would, if heavy, be rather distressing in a multi-cylinder engine of this design.

Three typical combustion diagrams, obtained with various shapes of cams, are shown in Figs. 14 to 16. The valve lift diagrams for the front and back fuel valves are also shown on the same angle base. An arbitrary figure for the intensity of detonation and other particulars are given against each combustion diagram. Although in the experimental opposed-piston engine there was no separate timing gear, and therefore it was not possible to modify the "timing" of the fuel valves when the engine was running, the fuel cams were adjusted so that the maximum pressure was limited to about 630 lb. per square inch.

In Fig 14., with short period cams in use, A B C is the diagram obtained when the engine was running at about 300 brake horse-power, but with the fuel momentarily cut off. F A B therefore represents, on an angle base, the compression curve, and B C F the expansion of the air previously compressed. The line F G gives the position of the indicator drum corresponding to the inner dead centre, i.e., when the pistons were at the end of the compression stroke. A D E represents the combustion diagram. In Fig. 14 the detonation figure is 5 on the arbitrary scale adopted. In Fig. 15 the cams give a slightly greater period of opening. Fig. 16 is a combustion diagram with long-period cams in use. In this case the fuel consumption is greater, and the detonation less, than with the short-period cams.

From the combustion diagrams shown in Figs. 14 to 16 the pressures in excess of the pressures given by the no-fuel compression-expansion diagrams were plotted on an angle base, and from these curves the rates of change of pressure were obtained. Fig. 17 shows the rate of pressure change curves. It will be seen that heavy detonation is accompanied by a high rate of change of pressure occurring just after the dead centre.

From the combustion diagrams temperature-entropy diagrams were also constructed for comparative purposes, with the assumptions that the temperature of the air charge at the beginning of compression was 200 deg. F. and that the weight of the working fluid was constant throughout the cycle. From the temperature-entropy diagrams the heat supplied and the temperatures throughout the cycle were plotted for each case, and from the heat supply curves the rate of the supply of heat was obtained. Fig. 18 shows the curves of rate of heat supply. It will be seen that in the case of the combustion diagram shown in Fig. 17, where the detonation was heavy, the rate of the supply of heat was greater than in the case of the low detonation diagram, Fig. 16.

From the various diagrams constructed the following points were clearly indicated:—

1. An increase in the rate of the supply of heat, i.e., in the rate of combustion of the fuel, resulted in heavier detonation.
2. In the case of low detonation diagrams heat was being supplied later in the expansion stroke than in the case of the high-detonation diagrams.
3. The maximum and mean temperatures of the cycle were greater in the low-detonation diagrams than in the high-detonation diagrams.
4. The thermodynamic efficiency was higher in the case of the high-detonation diagrams than in the case of low-detonation diagrams (this agrees with the fuel consumptions recorded).

From the experiments which were carried out it was clear that detonation was a function of the speed of injection with the particular oil fuel used, but when working at mean indicated pressures just above 130 lb. per square inch an increase in the quantity of fuel oil injected, other conditions remaining the same, tended to decrease detonation—although in this instance the exhaust did not remain colourless. Also, a reduction in the quantity of fuel injected tended towards decreased detonation.

Texas fuel oil was used during all these tests. There has been no opportunity to experiment with the object of determining to what extent the intensity of detonation is affected by the brand of fuel oil used.

Detonation is experienced in aircraft engines, but these engines draw in the fuel charge on the suction stroke, and towards the end of compression it is probable that a fairly homogeneous inflammable mixture is obtained. Ignition in this instance is by spark, and detonation is generally attributed to a pressure wave, caused by the ignition of a portion of the charge, compressing the remaining portion of the charge to a temperature above the spontaneous-ignition point of the fuel. On the other hand, in the case of the opposed-piston engine the fuel is injected towards the end of compression into air whose temperature is above the ignition point of the fuel. The mixture of fuel oil and air which is blown into the compression space through the two fuel valves is not at first inflammable, and it seems reasonable to suppose that ignition does not occur until the speed of the incoming charge is reduced, its temperature raised above the ignition point of the fuel oil and the distribution such that an inflammable mixture is obtained. When heavy detonation occurs, therefore, it is probable that there is a combination of circumstances favourable to rapid combustion, i.e., by the time the incoming charge of fuel and blast air has had its temperature raised above the ignition point of the fuel, either by admixture with highly heated air in the cylinder, by radiation from the small portion of fuel vapour which commences to burn on the fringes of the jets or by the formation of a pressure wave (as in the case of the aircraft engine), a large proportion of the fuel has been distributed generally in the compression space and an inflammable mixture obtained, with the result that combustion is extremely rapid.

It has been mentioned that when working at high mean pressures an increase in the quantity of fuel injected, other conditions remaining the same, tended to decrease detonation. In this instance it is probable that the additional fuel injected resulted in the formation of pockets too rich in fuel, and that combustion was consequently delayed. Although many experiments were carried out it has not so far been possible to run at high powers with Texas fuel oil at comparatively low fuel consumptions and at the same time avoid the detonation effect entirely. Generally speaking a reduction in the intensity of detonation resulted in increased fuel consumptions. It is probable, however, that better results may be obtained by further modifications to the fuel valves and cams. Detonation is not very noticeable in the laboratory 20 in. by 20 in. air injection, four-stroke cycle, single-cylinder experimental engine when using Texas fuel oil and running at high mean pressures at about 300 r.p.m. It would appear, therefore, that the type of engine has some influence on the intensity of detonation. As, however, the maximum pressures were approximately the same in the four-stroke engine and in the two-stroke opposed-piston engine it would seem to point to temperature as being one of the factors on which detonation depends, and not pressure.

So far as is known the spontaneous ignition temperatures of fuel oils have been determined hitherto, in either air or oxygen, at atmospheric pressure, by allowing drops of the fuel oil to be tested to fall on to a heated porcelain or into a platinum crucible, and noting the temperature at which the oil drops burst into flame. Although the results thus obtained are of value, and no doubt can be regarded as the true ignition temperatures of the apparatus used, it was felt that so far as Diesel engines were concerned these ignition temperatures could not be used directly for determining the compression ratio necessary to ensure the ignition of a fuel oil, when injected into an engine started from the cold condition. The method of injection and the quality of the fuel spray obtaining in the Diesel engine are not taken into account in these tests and the "time element" is for all practical purposes disregarded altogether.

When fuel oil is injected into an oil engine of the Diesel type the temperature at the end of compression necessary to ensure spontaneous ignition depends on the oil used, on the quality of the spray (i.e., the degree of pulverisation of the oil, which affects the speed of vaporisation preceding ignition), on the method of spraying the oil, and on the proximity of the spray to the water-cooled cylinder cover. Having these points in view, therefore, it was decided to design a piece of apparatus with the object of ascertaining, what might be termed, the practical ignition temperatures of fuel oils under conditions which approximate as closely as possible to the actual conditions obtaining in an engine. Knowing the practical ignition temperature of a fuel oil it was hoped that the lowest compression ratio necessary to ensure the ignition of the fuel in an engine, when starting from the cold condition, would be readily obtained from a temperature-compression curve.

A section through the cylinder and a diagrammatic arrangement of the apparatus is shown in Fig. 19. It will be seen that the apparatus consists of a steel cylinder A fitted at one end with a water-cooled cover B in which the fuel valve is situated. This cover is also fitted with compressed air and gauge connections C and D. At the other end of the cylinder a steel plate cover E, not water-cooled, is provided, which is held in position by the piston nut F and set screws. The cover E is fitted with a relief valve and indicator connection G and a heat-insulated sheath H which carries the thermocouple J. Provision was originally made for a fan to circulate the air in the cylinder and thus obtain a more uniform temperature before the injection of the fuel oil, but so far it has not been found of any great value.

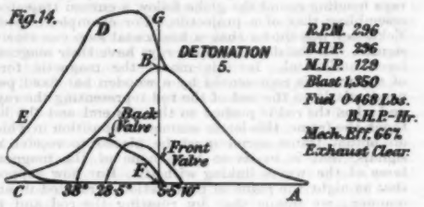
The steel cylinder, which is 5 in. internal diameter and 10¼ in. long, is fitted with a Brayshaw gas furnace, so that the compressed air contained in the cylinder can be brought to any desired temperature. When the cylinder is heated the temperature of the shell is slightly higher than the temperature of the air it contains, and in this respect, therefore, it differs from the water-cooled cylinder liner of an engine. The diameter was, however, fixed at 5 in. so as to ensure that with the fuel sprayer used the spray would not strike the heated shell.

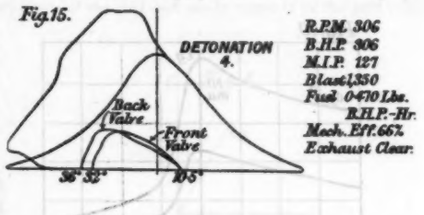
It was intended that both the solid and the air-injection systems should be tested and the fuel valve L was designed with this purpose in view. The fuel valve was, however, at first arranged for the solid-injection system and, as it was desirable that the quantity of fuel oil injected should only be sufficient to ensure an appreciable rise in pressure after combustion, the sprayer was provided with one hole 0·013 in. in diameter.

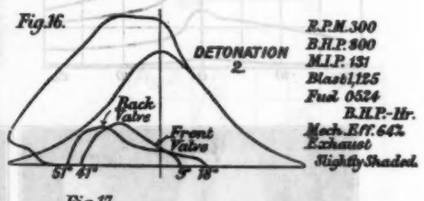
The fuel valve is operated by means of a falling weight W, released by a lever (not shown in the figure), which, after falling through a distance of about 1 ft., strikes the washer Y secured to a rod attached to the valve lever M.

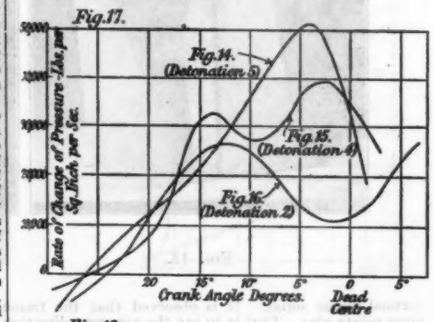
The fuel system is charged to the pressure required by means of a small pump placed near the apparatus.

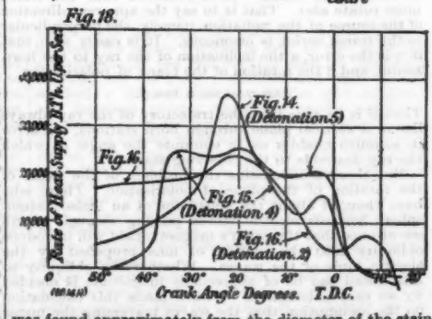
To ascertain the distribution of the fuel oil with the 0·013 hole sprayer a wooden plug, covered with white paper, was placed in the cylinder so that its surface was at right angles to the axis of the cylinder. The cylinder was then filled with compressed air to a pressure of 400 lb. per square inch at atmospheric temperature, and when a charge of fuel oil was injected the distribution











was found approximately from the diameter of the stain on the paper. By placing the plug in various positions, and injecting a charge of oil for each position, the distribution throughout the length of the cylinder was readily ascertained. It was found that when the plug was placed hard up against the cover E the paper was not completely covered with fuel oil, which indicated that little or no oil was striking the sides of the cylinder. In order that a false reading should not be obtained, however, by a portion of the spray striking the cylinder a sheet iron cup surrounded by an air space was fitted at a later date, as shown dotted in Fig. 19. The base of the cup was placed at the point of maximum temperature in the cylinder, i.e., about 3 in. from the end, and the thermocouple sheath passed through the base of the cup. It was found that the fitting of the cup made no appreciable difference in the results obtained, but it was thought desirable to retain it.

The cylinder is charged with compressed air from the laboratory air main and heated up to the required

* Abstract of a paper read before the North-East Coast Institution of Engineers and Shipbuilders, November 26, 1920.

temperature. The leakages of air from the fittings attached to the cylinder are very slight—the principal leak being past the indicator piston. This is overcome by charging the cylinder to a slightly higher pressure than that required for the experiment and injecting the oil as soon as the pressure has fallen to the required figure. As a matter of fact it has been found that there is little, if any, difference in the results obtained whether the pressure of air in the cylinder before combustion is 400 lb. or 200 lb. per square inch. Moreover, with the same sprayer it is found that at a given temperature the effect on the "time lag" is not very marked when the fuel pressure is varied between 2,000 lb. and 4,000 lb. per square inch. When the charge of fuel oil is injected into the cylinder and ignition has taken place, which is indicated by a rise in pressure and also by a slight rise in the temperature of the air, the cylinder is cleared out by relieving the pressure through the vent cock and blowing through the compressed air. In addition to the ordinary indicator for recording pressure rise a separate pencil attachment O is fitted, which is constrained to move vertically. This attachment is actuated by means of a steel tape 0·006 in. in thickness, which is connected to one arm of the bell-crank lever Z (Fig. 19), the other arm of the lever pressing against the end of the fuel-valve spindle. The movement of the fuel-valve spindle is therefore transmitted to the pencil and a valve-lift diagram is drawn on the paper carried by the continuous recorder N. A spring pulls the pencil attachment down when the fuel valve is closing, but it is only the instant of the opening of the valve which it is desired to avoid. The valve-lift pencil O is placed vertically above the ordinary indicator pencil, and valve lift and pressure diagrams are recorded on the same card. The indicator is placed about 8 in. from the cylinder cover to protect the spring from the heat of the furnace. The piston and cylinder of the indicator, as in the case of the indicators used with the experimental engines, are thoroughly cleaned after each test. It was found that the speed of the paper of the ordinary rotary recorder was insufficient, and a new indicator was obtained, giving a paper speed of 20 in. per second. Several timing devices were tried, but that now in use consists of a trembler coil, to which a pencil is attached, operated by a battery through a commutator driven by a constant-speed clock mechanism.

The temperature of the air in the cylinder is measured by a base-metal thermocouple J and an indicator R. The hot junction of the couple was made by brazing together the ends of "nichrome" and "ferry" metal wires. The cold-junction ends of the wires were fitted into glass tubes closed at one end and placed in water in a vacuum flask. The hot junction is placed in contact with the end of the sheath H, which is insulated from the cover with asbestos washers, &c. It takes an appreciable time to adjust the temperature of the air to that required for the experiment, and it is considered that the temperature of the end of the sheath, which is made as thin as possible, can, for all practical purposes, be taken as the temperature of the air in its vicinity.

The following experiment was carried out in order to ascertain the variation of the temperature of the air in the cylinder. The end cover E (Fig. 19), which corresponds to the piston of an oil engine, was removed and replaced by a thick sheet of asbestos millboard so that the position of the thermocouple could be readily varied. The air in the cylinder at atmospheric pressure was then heated up until a constant maximum temperature was reached. The thermocouple was then placed at various points on the centre line of the cylinder, and also in contact with the sides of the cylinder. Three sets of readings were taken and the mean temperatures obtained for each position of the thermocouple, for a maximum temperature of about 350 deg. C., are shown in Fig. 20. From the curve showing the temperature gradient on the centre line of the cylinder it will be seen that the maximum temperature is at a point about 3 in. from the air-cooled cover, and for a distance of 1 in. on either side of this point the temperature variation is not more than 5 deg. C. The greatest variation of temperature of the cylinder wall, as recorded by the couple placed close up to the wall, occurred at the top and bottom of the cylinder—the top being somewhat hotter than the air on the centre line. At a distance of 4 in. from the air-cooled cover the temperature of the air in contact with the cylinder top was about 10 deg. C. above that of the air on the centre line. This was the maximum temperature recorded. By making each ignition experiment on a very slowly falling temperature it is probable that such differences would be lessened, if not entirely eliminated. During the experiments the couple is placed at a distance of 3 in. from the end cover E, Fig. 19, and it is considered that the results obtained are accurate within ± 5 deg. C.

In a Diesel engine the temperature at the end of compression when starting from cold must be sufficient to ignite spontaneously the injected fuel oil in the time available. The initial temperature of the working fluid at the commencement of compression will be appreciably higher when the engine has been firing than when it starts from the cold condition. The cold condition is consequently the determining factor in regard to the compression ratio required for a given fuel oil, and in these experiments, therefore, the starting condition only has been considered. Assuming the equation $p v^n$ = constant between the initial and final compression pressures, the average value of n obtained from a number of compression cards taken from a four-stroke engine was 1·27, with compression ratios of 11 : 1 and 12·1 : 1. This engine was started with compressed air from the cold condition, and when the speed had reached that usually necessary to ensure the ignition of the injected fuel the starting air was shut off and the compression card taken.

Curves showing the temperature and pressure at the end of compression for various compression ratios are shown in Fig. 21. These curves are based on the following assumptions:—

(1) That the temperature of the air in the cylinder at the commencement of compression, when the engine is cold, is 10 deg. C. (50 deg. F.).

(2) That the volumetric efficiency when the engine is running on starting air is 100 per cent.

(3) That the index n of the compression curve is 1·27.

A number of combustion diagrams were taken when starting the four-stroke experimental engine referred to above from the cold condition, using shale-oil fuel with a compression ratio of 11 : 1, and it was found that to ensure an easy start the average time which elapsed from the point of opening of the fuel valve to the point at which the pressure began to rise above the "no-fuel compression-expansion" curve had to be of the order of 0·04 seconds. In the experiments which were carried out in the ignition-temperature apparatus, therefore, it was assumed that the ignition of the fuel-oil, as indicated by the rise in pressure, had to take place in 0·04 seconds from the instant the fuel valve commenced to lift.

In the preliminary experiments with the ignition apparatus a temperature was selected for an experiment, and the cylinder was filled with air at a pressure slightly higher than the pressure corresponding to the temperature obtained from Fig. 21 (full lines). The air was then heated up until the reading of the temperature indicator was steady at the desired temperature. As soon as the pressure of the air in the cylinder had fallen to the pressure corresponding to the temperature the indicator drum was set in motion and the weight, W, Fig. 19, allowed to fall, thus injecting a small quantity of fuel-oil into the cylinder. The pressure in the fuel-oil system had, of course, to be previously pumped up to that required for the experiment. The time which elapsed between the instant of opening the fuel valve and the instant the rise of pressure occurred, due to the combustion of the oil, was measured. If this differed from the time interval allowed further experiments were made at different temperatures and pressures until the correct time interval was recorded. By this means what has been termed the practical ignition temperature was obtained for the particular oil with the assumptions made.

Temperature of air before ignition		349 deg. C.
Rise of air temperature after ignition	...	5 deg. C.
Air pressure before ignition	...	200 lb. to sq. in.
Rise of pressure after ignition	...	170 lb to sq. in.
Fuel oil pressure	...	3,000 lb. to sq. in.

A portion of a diagram obtained from the apparatus, when using solid injection, is shown in Fig. 22. The oil used was shale fuel-oil having a specific gravity of 0·86 at 60 deg. F. The curve A B C shows the pressure in the cylinder. The pressure at A is 200 lb. per square inch, and the pressure at C, after the ignition of the oil, is 370 lb. per square inch—a rise of 170 lb. per square inch with the quantity of fuel-oil injected. The curve D E F G shows the fuel-valve lift, magnified in the original diagram about six times. The fuel valve opened at E and closed at F. The points H I J K, &c., were marked on the diagram by the timing device, and the average time interval is 0·019 seconds, i.e., the indicator paper travelled 1 in. in 0·052 seconds. The pressure in the fuel system was kept constant at 3,000 lb. per square inch.

It will be seen from this diagram that the indicator begins to show a rise of pressure in the cylinder at the point B, and the distance A B corresponds to a time interval of 0·068 seconds, i.e., the time which elapsed between the commencement of opening of the fuel valve and the indications of rise of pressure in the cylinder was 0·068 seconds. The temperature of the air in the cylinder when the oil was injected was 349 deg. C.

As the temperature in the cylinder of the ignition apparatus is increased the "time lag," represented by A B in Fig. 22, decreases. Fig. 23 shows the "time lag" so far obtained with shale fuel at various temperatures. It will be seen that at about 350 deg. C. the "time lag" increases rapidly as the temperature falls. The lowest temperature at which there was any sign of ignition shown on the indicator card was 260 deg. C., the lag being 3·5 seconds.

With shale fuel-oil, when using solid injection, it has so far been found that a temperature of about 380 deg. C. is required for a "time lag" of 0·04 seconds, but this temperature is much higher than the temperature at the end of compression of the experimental engine

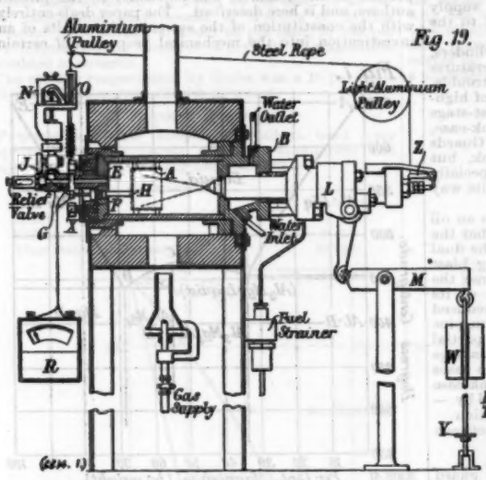


Fig. 19.

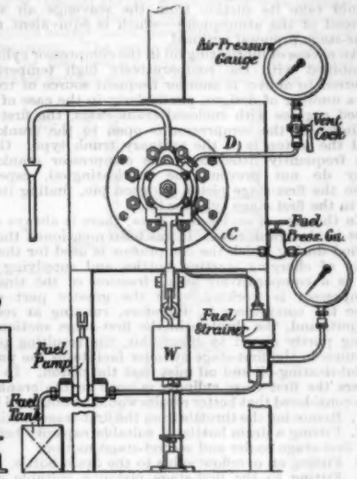


Fig. 20.

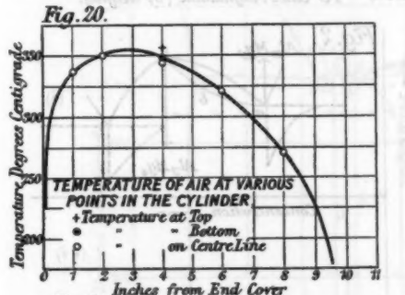

Temperature Degrees Centigrade
TEMPERATURE OF AIR AT VARIOUS POINTS IN THE CYLINDER
+ Temperature at Top
• - - Bottom
o - - on Centre Line
Inches from End Cover

Fig. 21.

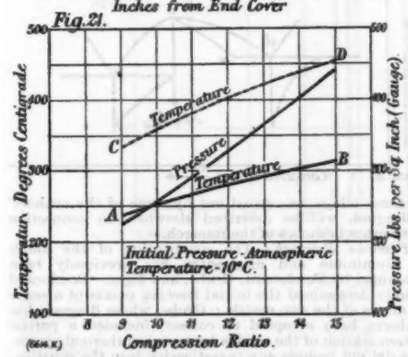


Fig. 22.

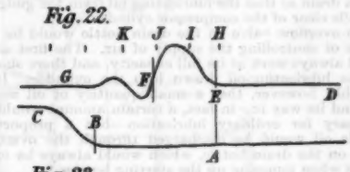
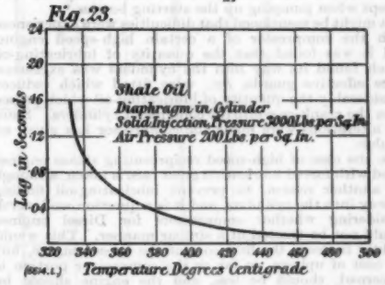


Fig. 23.


Lag in Seconds
Shale Oil
Diaphragm in Cylinder
Solid Injection. Pressure 3000 lbs per Sq. In.
Air Pressure 200 Lbs. per Sq. In.
Temperature Degrees Centigrade

(Fig. 21) with a compression ratio of 11 : 1—and the engine will start readily from cold with shale fuel-oil using this compression ratio.

In a Diesel engine, owing to the cooling effect of the piston, cover, and liner, the temperature of the air near the walls at the end of compression is less than the temperature of the air in the centre of the combustion space, *i.e.*, there is a hot zone in the centre of the combustion space, and it is through this hot zone that the fuel is sprayed. The temperature of the end of compression from Fig. 21, which is derived from the formula $p\,v^{1\cdot27} = constant$, is a measure of the mean temperature of the combustion space—but it is the maximum temperature of the combustion space, *i.e.*, the temperature of the hot zone, which causes the fuel-oil spray to ignite. It would appear, therefore, that the temperature obtained from the ignition apparatus is more a measure of the maximum temperature of the hot zone in the combustion space of the engine, and consequently the temperature-compression ratio curve A B in Fig. 21 cannot be used to ascertain the compression ratio to be employed to ensure an easy start from cold with a given fuel-oil. It is probable that the curve C D, shown dotted in Fig. 21, would be more nearly correct for this purpose, but this question is being further investigated. The maximum temperature of the hot zone in an engine, is of course, dependent on the shape of the combustion chamber.

Although a large number of tests have been made with shale fuel-oil, to ensure the satisfactory working of the apparatus, there has been no time to carry out many tests with oils of other brands. So far as the experiments have gone with shale-oil fuel it has been found that for the same quantity of fuel-oil injected an increase in the initial temperature of the air in the cylinder resulted up to a certain point in an increase in the maximum pressure rise and in a reduction in the "time lag." Above this point an increase in the initial temperature reduced the "time lag," but the maximum pressure rise due to the combustion of the fuel-oil began to decrease. This would appear to indicate that combustion was delayed at the higher temperatures, and it confirms the results obtained with the four-stroke engine during the tests with the hot plates, referred to on page 749. A few experiments were made with shale fuel-oil when using air injection, and it was found that it was necessary to have a temperature of about 40 deg. C. higher than the temperature with solid injection, for the same "time lag."

As previously mentioned some marine Diesel air compressors have been a continued source of trouble. Although there are many points to be considered the author would like to mention two, which, in his opinion, have been largely responsible for the difficulties which have been encountered in certain cases.

In nearly all cases a Diesel compressor is provided with sufficient capacity to charge the starting-air bottles as well as to provide the requisite quantity of blast air, and it frequently happens that the compressor is not designed from the point of view of the work it will be expected to perform during the greater part of its life. It has also been noticed—and a case occurred recently—that when a firm specialising in compressors is asked to supply a machine for coupling to a Diesel engine the only items generally specified are the maximum output required in free air per minute (which is fixed so as to ensure a good margin), the revolutions of the compressor and the maximum working pressure. No mention is made of the volume of air which will ordinarily be necessary for blast purposes. In consequence of this the compressor is designed for the full output, whereas most of its time it will be running at a reduced output for supplying blast air only.

As an example, let it be assumed that a three-stage compressor is designed so that the theoretical final temperature is the same in each stage. If the clearance volumes in the first, second, and third stages are taken as 4 per cent., 4 per cent. and 5 per cent. respectively, and it is assumed that the air-suction temperature is 70 deg. F., and that it is cooled to 70 deg. F. between the stages, the temperature at the end of each stage, obtained from theoretical diagrams, would be about 280 deg. F. for a final pressure of 900 lb. per square inch. If the compressor supplies blast air only, which is assumed to be seven-tenths of the full output, the maximum theoretical temperature will rise to 336 deg. F. owing to the increased ratio of compression. When supplying blast air only under working conditions, with tight valves, temperatures higher than 336 deg. F. would be reached on account of the increase in pressure necessary to cause the flow of air and to overcome the frictional resistance of valves and passages, dependent on the capacities of the intercoolers and on the arrangement of the stages. Further, it is also probable that after the first stage the initial temperatures of the second and third stages would be higher than 70 deg. F. There is no doubt that in certain circumstances very high final temperatures are obtained and small explosions in pipes, &c., which have affected the good working of the valves, have not been exceptional.

From the point of view of maximum air temperatures, therefore, it is considered preferable to fix the staging so as to get the minimum stage temperatures when the compressor is supplying blast air only. As an alternative, should the general arrangement of the machinery permit of this, a four-stage compressor could be fitted. In the alternative scheme the first stage would be of sufficient capacity to give the full output required for charging the starting-air bottles and providing the blast air, and the second stage would be of sufficient capacity for providing blast air only, with a small margin. When charging starting-bottles all stages would be in use and there would be four stages of compression, but when providing blast air only the first stage would be cut out entirely and the second, third, and fourth stages would operate as a three-stage compressor—the second stage then taking its suction from the atmosphere. The dimensions of the third and fourth stages would be fixed so as to give the minimum final temperatures in the second, third, and fourth stages when supplying blast air only. It is not necessary to go into the question of the arrangement of suction pipes with this proposal but no difficulties are anticipated.

With the four-stage proposal, when supplying blast air only, the second stage virtually becomes the first stage of a three-stage compressor, and it is pumping at practically its full output. The difference in volume between the first and second stages would, of course, depend on the extra output required for charging starting-air bottles. In the case of a compressor attached to a two-stroke engine, when the scavenging pressure is from 3 lb. per square inch to 4 lb. per square inch, a three-stage compressor could be fitted, and arrangements made so that when charging starting-air bottles the first stage would take its suction from the scavenge air supply instead of the atmosphere—which is equivalent to the four-stage proposal outlined.

An excess of lubricating oil in the compressor cylinders, combined with the comparatively high temperatures referred to above, is another frequent source of trouble. In a number of designs, particularly in the case of high-speed engines with enclosed crank-cases, the first-stage cylinder of the compressor is open to the crank-case, and the piston is of the ordinary trunk type. Guards are frequently fitted over the compressor crank, but they do not prevent the lubricating-oil, especially from the first-stage piston gudgeon pin, finding its way on to the first-stage cylinder liner.

In the case of enclosed engines, there is always an oil mist in the crank-case. It has been mentioned that the period during which the compressor is used for the dual duty of charging starting bottles and supplying blast air is a comparatively small fraction of the time the compressor is working. For the greater part of its time the compressor is, therefore, running at reduced output, and, the throttle in the first-stage suction pipe being partly closed to effect this, the resulting partial vacuum in the first-stage cylinder facilitates the passage of lubricating-oil and oil mist past the piston. In cases where the first-stage cylinder is open to the crank-case it is considered that better results would be obtained by —

1. Removing the throttle from the first-stage suction.
2. Fitting a drain bottle of suitable capacity between the first-stage cooler and second-stage suction.
3. Fitting an overflow valve to the drain bottle.
4. Fitting to the first-stage piston a suitable guard with a drain so that the lubricating-oil from the gudgeon pin falls clear of the compressor cylinder.

The overflow valve on the drain bottle would be the means of controlling the supply of air. The first stage would always work at its full capacity, and there should be less lubricating-oil drawn into the cylinder. It is probable, however, that a small quantity of oil would still find its way in—in fact, a certain amount would be necessary for ordinary lubrication—but a proportion of this oil would be discharged through the overflow valve on the drain bottle, which would always be open except when pumping up the starting bottles.*

It might be mentioned that difficulties were experienced with the compressor of a certain high-speed engine, and it was found that the quantity of lubricating-oil which found its way into the cylinders was excessive. More effective guards, &c., were fitted which reduced considerably the quantity of lubricating-oil which passed from the crank-case into the compressor cylinders. Since the alterations were made the compressor has given no trouble.

In the case of high-speed reciprocating steam engines fitted with forced lubrication great care is taken, although for another reason, to prevent lubricating-oil finding its way into the cylinders, and it is a question well worth considering whether compressors for Diesel engines should not be treated in a similar manner. This would slightly increase the first cost of the Diesel engine, but the cost of upkeep, so far as the compressor portion is concerned, should be less, and the engine should be more reliable.

It is considered, therefore, that by giving closer attention to the staging of the compressor, and also designing and arranging it with the view of reducing the chances of lubricating-oil passing into the cylinders in excessive quantities, the troubles with compressors should be considerably reduced, if not entirely eliminated.

The air compressor question has frequently been considered at the Admiralty Engineering Laboratory, and an arrangement has been devised following on the lines of Trinkler's proposal. Should such a system be found in every way satisfactory it would result in an appreciable reduction in the number of vital parts in a compressor.

The experimental work which has been outlined in this paper is concerned principally with the high-speed engine, but the injection of fuel-oil is equally important in the case of the slow-speed engine, and several of the questions dealt with are common to both types. In some cases, particularly in the case of the ignition experiments, the results given are not as complete as one would wish, as the experiments are proceeding, but it is hoped that what has been given will prove of interest to the members of the Institution, and that the reasons advanced for certain occurrences will stimulate discussion.

In conclusion, the author desires to express his thanks to the Admiralty for permission to read this paper, and to the staff of the Laboratory, especially to Mr. Newman, Chief Designer, and Mr. Aitken, Chief Testing Engineer, for their valuable assistance in connection with the experimental work. The author also wishes to acknowledge the valuable assistance rendered by Dr. O. F. Hudson in connection with the ignition experiments.

* In the air compressor constructed by Messrs. Reavell the supply of air is controlled by means of the drain valve between the first and second stages.

THE CONSTITUTION OF THE ALLOYS OF ALUMINIUM AND MAGNESIUM.*

By D. HANSON, M.Sc., Member, and MARIE L. V. GAYLER, B.Sc., Member.

(*From the National Physical Laboratory.*)

In connection with an extensive research on aluminium alloys, carried out in the Metallurgy Department of the National Physical Laboratory under the direction of Dr. W. Rosenhain, F.R.S., it became desirable to determine as accurately as possible the constitution of the binary alloys of aluminium with magnesium. This portion of the research was entrusted to the present authors, and is here described. The paper deals entirely with the constitution of the system; the results of an investigation into the mechanical properties of certain

Fig. 1.

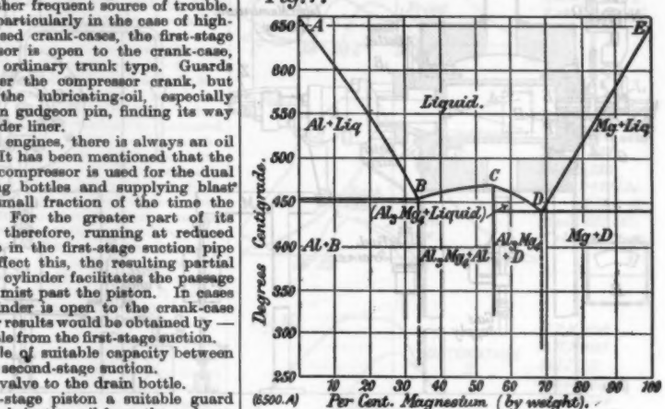
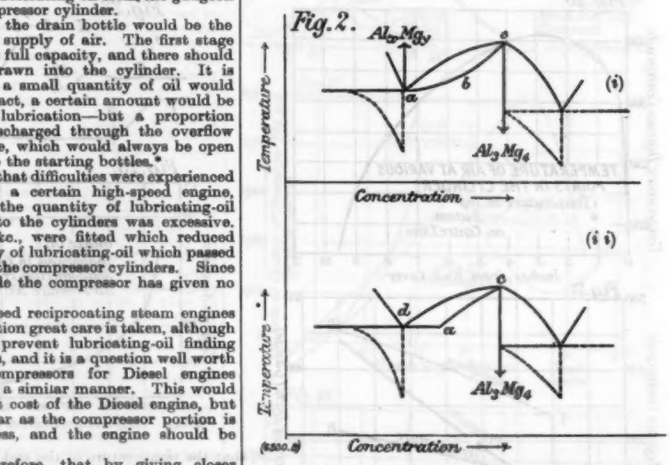


Fig. 2.



The experimental work which has been outlined in this paper is concerned principally with the high-speed engine, but the injection of fuel-oil is equally important in the case of the slow-speed engine, and several of the questions dealt with are common to both types. In some cases, particularly in the case of the ignition experiments, the results given are not as complete as one would wish, as the experiments are proceeding, but it is hoped that what has been given will prove of interest to the members of the Institution, and that the reasons advanced for certain occurrences will stimulate discussion.

of these alloys, as carried out by some of the authors' colleagues, will be described elsewhere in connection with other branches of the research.

Previous Research.—The constitution of the alloys of aluminium and magnesium has previously been examined by Boudouard, Grube, and Eger. Boudouard merely determined the initial freezing points of a series of alloys of the two metals; Grube, whose diagram has hitherto been accepted as correct, included a partial determination of the solidus by means of thermal curves, but did not include any investigation into the constitution of the solid alloys, other than that afforded by an examination of the microstructure of a few specimens. Grube's diagram is shown in Fig. 1. According to this the two metals form a chemical compound to which the formula Al_3Mg_4 is given. This compound forms a well-defined eutectic with magnesium, having a melting point of 440 deg. C., and containing 68 per cent. of magnesium (by weight). In the case of the alloys of the compound Al_3Mg_4 and aluminium, the constitution is not so clear. Along the line BC (Fig. 1) crystals of a solid solution are deposited, which may be either a solid solution of Al_3Mg_4 with a second compound Al_2Mg_3, or with aluminium. Grube suggests two forms of diagram corresponding to these two hypotheses. These are shown in Fig. 2 (i) and (ii). In the diagram (i) a definite compound is formed at *a*, obeying the laws of multiple proportions, the nearest probable compositions being Al_3Mg_2 (37·50 per cent. magnesium) and Al_2Mg (32·21 per cent. magnesium). In the

* Abstract of a paper read before the Institute of Metals, at Barrow-in-Furness, on September 15.

diagram (ii) the crystals separating out between 33 per cent. and 55 per cent. magnesium consist of a solid solution of Al_3Mg_4 and aluminium. In all the alloys in this region the beginning and end of the solidification range are so close together that it is impossible to distinguish them practically, and no evidence can therefore be obtained from them to decide which is the more correct diagram.

Microscopic examination of the alloys, however, showed that—

1. From 0 per cent. to 35 per cent. aluminium they consist of primary crystals of an aluminium rich-solid solution surrounded by another solid solution containing about 35 per cent. of magnesium. At a concentration of about 30 per cent. magnesium the primary crystals have a dendritic form, which led Boudouard to give them the formula Al_4Mg. 2. From 35 per cent. to 54 per cent. magnesium the alloys consist of homogeneous solid solution. 3. From 54 per cent. to 68 per cent. magnesium they consist of crystals of Al_3Mg_4 embedded in eutectic. 4. From 68 per cent. to 100 per cent. magnesium they consist of crystals of magnesium embedded in eutectic.

The etching reagent used by Grube was a 10 per cent. solution of ammonium chloride in water.

THE PRESENT RESEARCH.

Preparation of the Alloys.—The alloys used were prepared from the purest available aluminium and magnesium of the following compositions:—

Aluminium.

	Per cent.
Iron	0·29
Silicon	0·17
Aluminium (difference)	99·54

Magnesium.

	Per cent.
Iron	0·1
Silicon	0·033
Zinc	0·019
Manganese	0·029
Copper	0·069
Lead	nil
Magnesium (difference)	99·75

Those containing up to 35 per cent. magnesium were made by adding the requisite amount of magnesium to molten aluminium. With the high magnesium contents, some difficulty was experienced in preventing burning of the alloys after the magnesium had been added, but this was not serious in the range of composition mentioned above. The alloys containing 35 per cent. to 70 per cent. magnesium were prepared as follows. Two "stock" alloys containing approximately 35 per cent. to 70 per cent. magnesium respectively were first prepared, in relatively large quantities, by adding metallic magnesium to molten aluminium. These were then analysed, and used for preparing alloys of intermediate compositions. Since they have very low melting points this operation was carried out without appreciable loss due to burning. In the case of the alloys rich in magnesium, this constituent was first melted carefully without overheating, and the aluminium added. In the preparation of these alloys the greatest possible care was taken to avoid contamination at any stage. The fire-clay crucibles used were all coated with a "wash" of pure alumina or magnesia. The alloys were cast partly in metal moulds and partly into previously warmed magnesia- or alumina-coated crucibles of a special shape, for use in taking the thermal curves. Fig. 3 shows the shape of these crucibles. A thermocouple protecting tube is inserted from the side and projects well into the metal; a depth of immersion equal to approximately two-thirds of the diameter of the crucible is desirable unless the diameter of the crucible is very large compared with the diameter of the thermocouple protector. This type of crucible gives a large depth of immersion of the thermocouple even when the mass of the metal is small, and when a gradient furnace * is used a shallow ingot is preferable. This type of crucible has been designed for use with this furnace. In order to minimise the danger of burning of the alloy during the taking of thermal curves, the crucibles were covered with lids which were luted in place. This was effective with all alloys except those containing more than 90 per cent. magnesium. The latter gave satisfactory heating curves on the first heating, but on subsequent cooling a considerable evolution of gas took place, which forced

Fig.3.

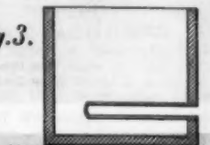
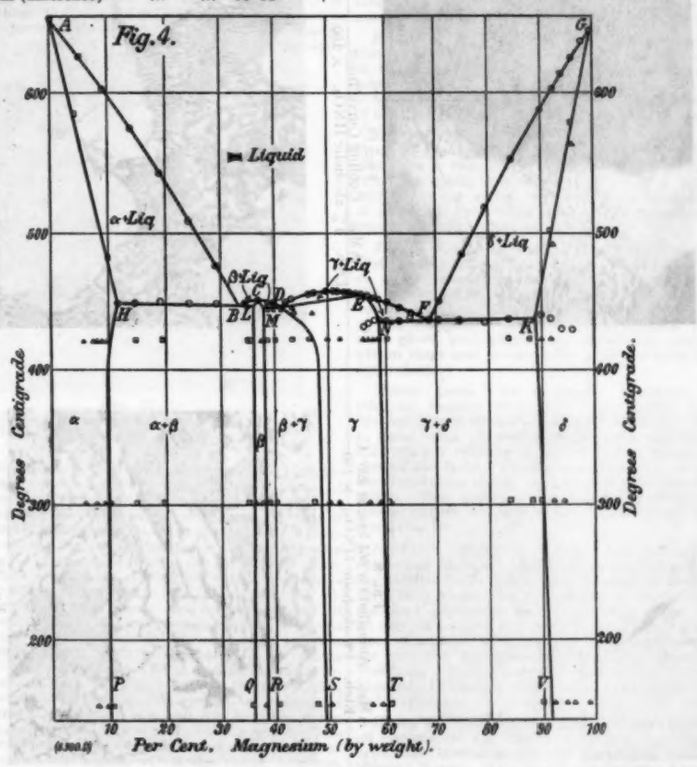


Fig.4.



the metal out of the crucible, either at the junction of the couple protector and crucible, or between the lid and the crucible. On coming into contact with the hot air of the furnace, the metal became ignited. After a number of devices had been tried without success, it was found that by drilling a small hole in the lid, by means of which the evolved gases could escape, the trouble was prevented. No flux of any kind was used for the protection of any of the alloys.

The alloys used during the course of the research, together with their chemical compositions and identifying marks, are given in an appendix to the paper. All were marked AM, the number following being the intended composition in percentage weight of magnesium. Thus AM_{35} denotes an alloy intended to have a composition of 35 per cent. magnesium. The differences between intended and actual composition are very small, with the exception of one or two alloys. For the chemical analyses the authors are greatly indebted to Mr. W. H. Withey, B.A., by whom they have all been carried out.

Thermal Curves.—The thermal curves were carried out in a gradient furnace in the type of crucible already described. The temperatures were measured by means of a platinum-iridium thermocouple which, at frequent intervals during the research, was calibrated against the melting points of tin, lead, zinc, and aluminium. The cold junction was kept surrounded by ice in a vacuum vessel. The results were obtained in the form of inverse-rate curves by means of the Rosenhain plotting chronograph.*

The results of the thermal curves are shown in an appendix to the paper in which the points followed by a query mark were of very small dimensions indeed, and it was in some cases doubtful whether they were due to changes taking place in the alloy.

The transformation points indicated by the thermal curves are plotted on the diagram (Fig. 4), the points found on heating curves being indicated by means of a circle, and those obtained from cooling curves by a cross. The observations differ from those of Grube, chiefly in that there is a small indication of a second maximum in the liquids curve at a composition of about 38 per cent. magnesium. The temperature interval between maximum and minimum is, however, only 2 deg. C. to 3 deg. C., and further confirmation was required before a modification of the diagram on this account could be accepted. In no part of the diagram over the range of composition 35 per cent. to 55 per cent. magnesium was it possible to detect more than one arrest point during solidification, and no assistance was obtained from this evidence in determining the shape of the diagram in this region. A small point is found on the curves of AM_5, AM_{10}, AM_{15}, AM_{20}, AM_{25}, AM_{34}, AM_{38}, AM_{34}, AM_{100}. In the case of the aluminium-rich alloys, this is due to the presence of a small amount of iron as an impurity; it is probably due to the same cause in the magnesium-rich alloys. The alloys AM_{37}, AM_{40}, AM_{42}, AM_{44}, give a very small point at about 433 deg. C. This was obtained on the heating curve, and not on subsequent cooling; it is thought that it is probably due to a non-equilibrium condition in the relatively quickly cooled alloy which was used for the heating curve. Small specimens of the alloys were quenched above and below this point, but no evidence was obtained of any change in the alloys connected with it.

Thermal Treatment and Microstructures of the Alloys.—Polished sections of most of the alloys were examined in the condition in which they existed after thermal curves had been taken; in addition, samples of chill cast alloys were submitted to long annealings in order to determine the constitution after full opportunity had been given for true thermal equilibrium to be obtained; the alloys used in the determination of the thermal curves, while not in true thermal equilibrium, often afford valuable evidence as to the interpretation of the data obtained by means of the thermal curves. The diagram which has been arrived at as a result of this research is given in Fig. 4, and will be described in detail, together with the evidence on which it is based.

The liquidus curve ABCDEFG consists of four branches with maxima at the points C and E. These maxima correspond approximately to the compositions of the compounds Al_3Mg_2 and $AlMg_3$. The line AB marks the beginning of the separation of a solid solution α, which is essentially aluminium, in which the compound Al_3Mg_2 is dissolved. Up to compositions represented by the point B, solidification takes place first by the separation of α from the liquid alloy. Alloys containing less magnesium than is represented by the point H, when in equilibrium, are found immediately after solidification to consist entirely of α; but in the other alloys over this range, solidification of the residual liquid takes place at 448 deg. C. The intensity of the arrest at this temperature increases as B is approached, and reaches a maximum at that point, at which composition the alloy shows only the one arrest point. Typical microstructure of the alloys in this region are shown in Figs 5 to 7.

Fig. 5 shows the structure of an alloy containing 20 per cent. of magnesium. The white constituent is the solid solution α, while the dark etching portions have solidified at the constant temperature arrest point at 448 deg. C. In Fig. 6, which represents an alloy containing 30 per cent. magnesium, the amount of the white constituent is considerably less and the dark etching constituent is correspondingly increased. Fig. 7 shows an alloy containing 35 per cent. magnesium. The composition of this alloy practically corresponds with that of the point B; it is seen that the material has a duplex structure, which confirms the view that the line HL represents the separation of an eutectic of the two constituents α and β. The alloys from which the photomicrographs were taken had been subjected to a long annealing in order to give them every opportunity to attain equilibrium. They did not, however, differ sensibly from the alloys which had been slowly cooled during the taking of the cooling curves. The curve BCD corresponds to the separation from the liquid of a second constituent, which has already been referred to as β; the maximum point C lies at a composition almost exactly the same as that of the compound Al_3Mg_2 moreover, the alloy of this composition has a homogeneous structure when examined under the microscope. This is shown in Fig. 8, which includes the junction of two of the homogeneous crystals. The addition of small amounts of either aluminium or magnesium to this alloy results in the formation of an alloy containing two constituents. This evidence, therefore, appears to justify the conclusion that the constituent β is identical with the compound Al_3Mg_2. This compound and alluminium form a simple eutectiferous series with one another, the eutectic point being near the composition of the compound. The temperature of the eutectic arrest is very close to the melting point of the compound; there is not more than about 2 deg. C. between them. It was, therefore, impossible to distinguish the arreste

*See W. Rosenhain, "Some Appliances for Metallographic Research," Journal of the Institute of Metals, No. 1, 1915, vol. xiii page 160.

* Rosenhain, Journal of the Institute of Metals, No. 1, 1915, vol. xiii, page 160.

THE CONSTITUTION OF THE ALLOYS OF ALUMINIUM AND MAGNESIUM.

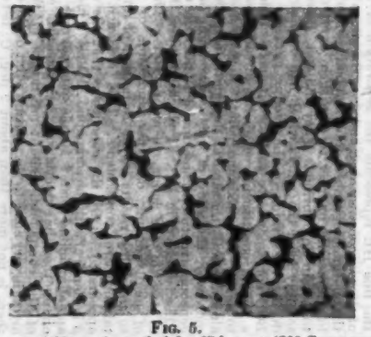


FIG. 5.
AM_{36}. Annealed for 67 hrs. at 420° C.
Etch. 1% alcoholic HNO_3. × 150.

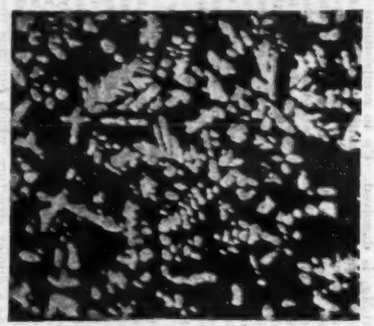


FIG. 6.
AM_{36} Annealed for 55 hrs. at 400° C.
Etch. 1% alcoholic HNO_3. × 150.

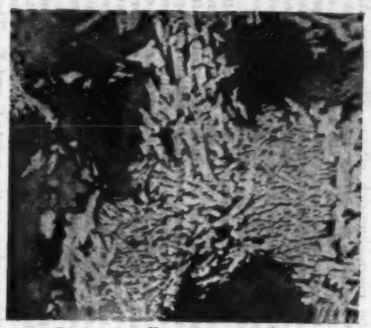


FIG. 11.
AM_{43}. Cooling Curve Ingot.
Etch. 1% alcoholic HNO_3. × 150.

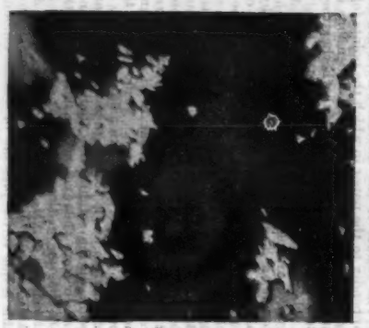


FIG. 12.
AM_{44}. Cooling Curve Ingot.
Etch. 1% alcoholic HNO_3. × 150.

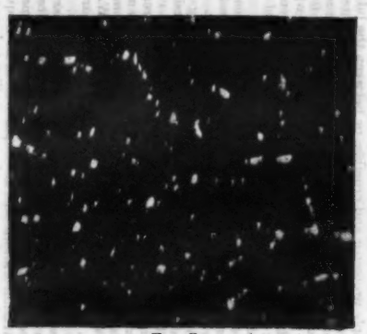


FIG. 7.
AM_{35}. Annealed for 55 hrs. at 400° C.
Etch. 1% alcoholic HNO_3. × 150.

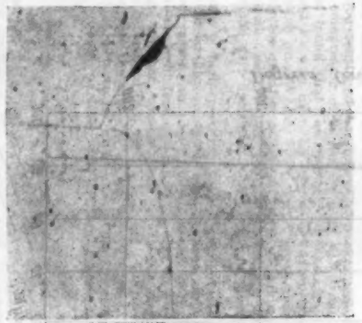


FIG. 8.
AM_{37}. Annealed for 26½ hrs. at 420° C.
Etch. 1% alcoholic HNO_3. × 150.

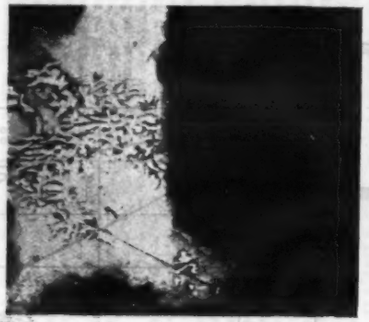


FIG. 13.
AM_{42}. Cooling Curve Ingot.
Etch. 1% alcoholic HNO_3. × 150.

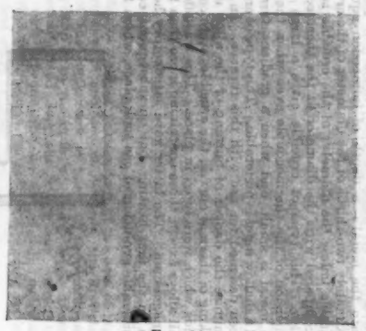


FIG. 14.
AM_{51}. Annealed for 9 days at 440°C.
Etch. 1% alcoholic HNO_3. × 150.

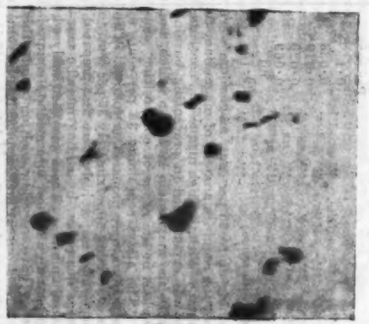


FIG. 9.
$AM_{39.5}$. Annealed for 64 hrs. at 420° C.
Etch. 1% alcoholic HNO_3. × 150.

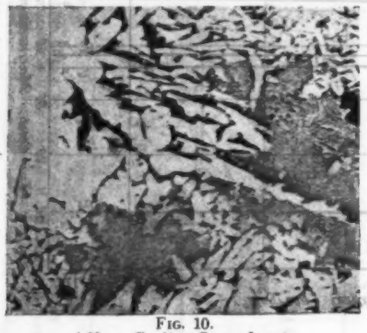


FIG. 10.
AM_{40}. Cooling Curve Ingot.
Etch. 1% alcoholic HNO_3. × 150.

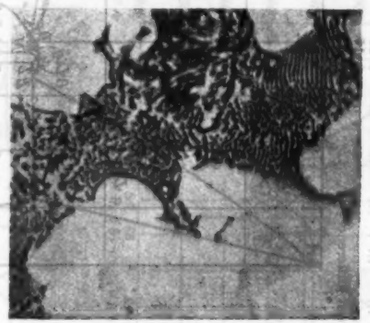


FIG. 15.
AM_{62}. Chill Cast. Unetched. × 1000.

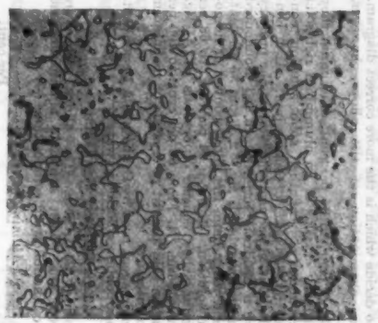


FIG. 16.
AM_{53}. Chill Cast. Unetched. × 150.

corresponding to the primary separation over the range BC from those due to the eutectic; the alloys in this region appeared to have only one arrest point. The study of the microstructures, however, leaves little doubt as to the actual form of the diagram in this region. The addition of magnesium to β soon results in the appearance of a third phase, which may be called γ. This is present in the alloy containing 38·5 per cent. magnesium, as is shown in Fig. 9, where the γ appears dark. The etching properties of the alloys in this region are of interest. So long as the alloy consists of pure β or of α and β, the β constituent is attacked by the etching reagent, though the attack is very slow when α is absent. When γ enters into the alloys it is the first to be attacked by the reagent, with the result that the γ is protected and appears white. Thus in Fig. 9 the white constituent is β, which in the previous photographs has appeared dark. It appears to be general throughout the series of alloys that the constituent richest in magnesium is attacked preferentially by the etching reagent used. The appearance of the constituent γ does not seem to be accompanied by the occurrence of a second arrest on the thermal curves. The microstructures of the ingots which have been used for the determination of the thermal curves, however, gave a clear indication of the method of solidification. Fig 10 and 11 show the structures of the cooling curve ingots of the alloys containing respectively 40·5 per cent. and 42·2 per cent. of magnesium. The alloy containing 40·5 per cent. magnesium consists of primary crystals of β embedded in an eutectic. The alloy containing 42·2 per cent. magnesium consists of primary crystals of γ embedded in the same eutectic. It is evident, then, that an alloy of eutectic composition must exist between these two compositions, an assumption which agrees well with the shape of the liquidus

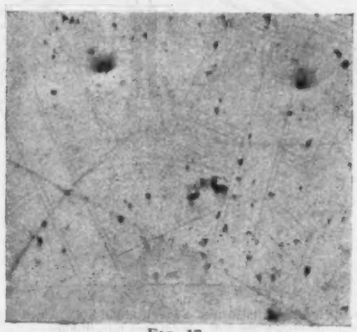


FIG. 17.
AM_{20}. Annealed 52½ hrs. at 420° C.
Etch. 1% alcoholic HNO_3. × 280.

curve in this region. Also, it is clear that the eutectic temperatures cannot be very different from those of the liquidus temperatures of the alloys referred to above; the difference is certainly not of such an order that it can be determined by means of thermal curves. Here again, however, the microstructures indicate clearly the character of the solidification of the alloys. This eutectic also occurs in the cooling curve ingots of alloys AM_{44} and AM_{48}, as is shown in Fig. 12 and Fig. 13. Alloys containing still more magnesium consist of homogeneous γ (Fig. 14), until a composition of about 60 per cent. of magnesium is reached, when another constituent appears. This constituent, δ, separates from the liquid along the line EFG, and forms a characteristic eutectic with γ. Fig. 15 shows the alloy AM_{52} in the "as cast" condition. It consists of primary δ and an eutectic consisting of γ and δ. Fig. 16, of the alloy AM_{55}, shows primary γ and eutectic $\gamma + \delta$. The typical formation of the eutectic is not so well marked in the alloys in this region. Over this range, however, the eutectic arrest is clearly defined, and distinct from that due to the primary separation. Alloys containing from 90 per cent. to 100 per cent. magnesium consist of homogeneous δ, which is essentially magnesium, containing dissolved γ. Fig. 17 shows an annealed specimen of alloy AM_{20}; it consists of a single homogeneous solid solution.

The data obtained from thermal curves, and from the examination of ingots which had been used in the determination of those curves, gave a fairly clear indication of the general character of the equilibrium diagram of the alloy system. The rate of cooling used in the determination of thermal curves is, however, not sufficiently slow to allow the alloys to attain complete equilibrium, and special methods had to be adopted to obtain a true diagram of the equilibrium conditions of the alloys at all temperatures, and especially at temperatures below the solidus of the alloys. Moreover, the solidus itself can only be determined from cooling curves in alloys in which eutectic exists. Eutectics, however, sometimes form, through lack of uniformity of composition, in alloys in which they would not be present if sufficient time were given during cooling for complete equilibrium to be obtained. In order to determine the true limits of the different fields of existence of the phases, series of alloys in the neighbourhood of the phase-field boundaries have been submitted to prolonged heat treatment. These treatments have in many cases extended for a period of days in order that sufficient time should be given for diffusion to become complete. The resulting structures were in all cases preserved by quenching the alloys after the desired treatment had been carried out. For the determination of the actual solidus suitable alloys, after this prolonged annealing to obtain uniformity of composition, were heated to successively higher temperatures, followed by quenching, until microscopic examination of the specimens showed that liquefaction had commenced. In carrying out these heat treatments considerable use has been made of the high temperature thermostat designed by one of the authors and Mr. J. L. Haughton.* With this apparatus temperatures up to 1,000 deg. C. can be maintained for an indefinite period accurate to 1 deg. C. It has also been used in many experiments, which will be described, in which a very slow fall of temperature was required. By its use long time annealings were carried out with little trouble and great accuracy, and much work was rendered possible which would otherwise have been difficult, if not impossible, to carry out. The authors have found this instrument of the greatest use in the investigation of thermal equilibrium.

(To be continued.)

* Haughton and Hanson, Journal of the Institute of Metals, No. 2, 1915, vol. xiv, page 145; No. 2, 1917, vol. xviii, page 173.

CATALOGUES.

Cranes.—A series of electrically-driven cranes, including overhead travellers, transporters, floating cranes and ladle cranes, is shown in a catalogue issued by the Wellman, Smith, Owen Corporation, Limited, Darlaston.

Vibration of Machinery.—A useful little booklet on the elimination of vibrations from buildings, ships, machinery, &c., comes from the Vibration Specialty Company, of Philadelphia, U.S.A., who make balancing machinery and instruments for use in this connection.

Pressed Steel Railway Trucks.—The Pressed Steel Car Company, Pittsburg, U.S.A., send a catalogue of trucks of large capacity made of pressed steel framing with hopper openings in the bottom discharging the load clear of the track on either side. One example carries 44 tons of coal and clears itself of 99 per cent. of the load.

Drilling Machines.—A catalogue from the Niles Bement Pond Company, 111, Broadway, New York, describes a radial arm drilling machine which differs from the usual type mainly in having a double pillar with four vee slides, on their inner surfaces, instead of the usual cylindrical pillar. The general details are carefully designed for easy operation.

Piston Rings.—A wall sheet issued by the British Piston Ring Company, Limited, Coventry, gives tables of motor cars, cycles, vehicles and tractors, stating the name, type, diameter and width of piston ring required and a related number by which a piston ring of the company's make may be ordered. The sheet also gives instructions for measuring and applying piston rings and some useful tables of inch and metric equivalents.

Turret Lathe.—An operator's handbook (fifteenth edition), dealing with their turret lathe, comes from Messrs. Alfred Herbert, Limited, Coventry. It contains a great deal of well-arranged and clearly-expressed information relating to the erection, adjustment and care of the lathe; the equipment for special jobs; and care in setting tools; and also includes speed and feed tables. The operator who wishes to obtain complete mastery of his machine and his work will gain much help from this book.

Stacking Machines.—These are portable lifting appliances for use in large stores for lifting bales, casks and similar loads to a height required for stacking. The drive is by electric motor mounted on the frame, and the standard capacities are for hoisting from 3 cwt. to 25 cwt. to heights of from 8 ft. to 18 ft. A number of sizes are made within these limits and several types are adapted for special work. The makers are the Wellman, Smith, Owen Engineering Corporation, Limited, Darlaston, who send a catalogue illustrating and explaining the machines.

Heavy Oil Engines.—A series of standardised heavy oil engines, of the vertical two-cycle high compression type, are described in two catalogues received from Messrs. Norris, Henty and Gardeners, Limited, 115, Queen Victoria-street, London, E.C. 4. These comprise five stationary sizes of 3½ brake horse-power to 15 brake horse-power; a series of multi-cylinder combinations up to 120 brake horse-power; and also marine engines. In addition to being very economical in fuel consumption, the engines, it is claimed, run satisfactorily with variable loads, and can also be run at very low speeds.

Small Marine Engines.—The catalogue of marine engines, running on oil or petrol, has been issued by Messrs. John I. Thornycroft and Co., Limited, 10, Grosvenor-place, London, S.W. 1, and will be found useful to all having the ownership or care of small craft requiring a propelling power of 15 brake horse-power to 90 brake horse-power. The craft illustrated as fitted with these engines have speeds ranging from 5 knots to 39 knots. The engines are fully and carefully described, and precise particulars are given of powers, weights, dimensions, space occupied, &c.; drawings are also included.

Steels.—A handbook on carbon and alloy steels issued by Messrs. Thomas Firth and Sons, Limited, Sheffield, should prove particularly useful to practical engineers who have to select steels with the special qualities required for gears, springs, valves, &c., and for parts subjected to high temperature, shock, corrosive influences, &c. Typical uses to which each steel may be put are mentioned, and the usual test results are given in each case. There are also notes and tables on case-hardening, and air-hardening, weights of bars, conversion of weights, temperature measurements, thickness and weight of sheets, and much other matter that will make the book a very handy work of reference.

Thrust Bearings.—A catalogue issued by Michell Bearings, Limited, 3, Central Buildings, London, S.W. 1, shows a thrust bearing which is now produced in a series of standard sizes for vertical or horizontal shafts, from 1 in. diameter to 6 in. diameter. It is termed a "thrust slipper," and consists of two of the Michell blocks, which extend over a segment of about one-fifth of a circle. These are fitted in a frame and applied, for example, to the under side of a flange secured on a horizontal shaft. If the thrust may be applied in either direction, two slippers are employed, one on each side of the flange. The bearing is supplied complete with bearing blocks, housing, oil reservoir and flange, or without housing and flange. The standard patterns may be applied to a great many ordinary uses.

Shipbuilding.—A descriptive and historical account of their great shipyards on the Tyne has been issued by Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, in the form of a handsomely printed and illustrated book containing 50 pages in a strong binding. It is of special interest as it consists of a brief review of one department of one of the greatest industrial establishments in the world, including nearly every variety of naval and mercantile shipbuilding, with hulls, machinery, fittings and armament, all of which emanate from shops and industries under one co-ordinated management. It would be well if, in addition to being circulated among shipping interests, the book could be added to some of our public libraries in order to show the general public something of our great industries.

Oxygraph.—The oxygraph described in a catalogue received from the Davis Bournonville Company, Jersey City, U.S.A., is an oxy-acetylene blowpipe provided with pantograph mechanism for cutting out irregular shapes from steel slabs or billets up to 20 in. thick. One of the examples illustrated shows a cutting from a piece of steel 6 in. thick; consisting of two collars united by a web in which one hole is round and of 7¼ in. diameter, and the other hole hexagon and 8 in. across the flats. The walls are ¾ in. thick, and of very even shape, nearly as accurate as a casting; it is certainly a remarkable piece of work. The comparative cost of cutting a similar but heavier piece is stated in detail, a completely forged piece, including material, costing 195 dols., and a cutting from a forged blank 136 dols., a saving of about 30 per cent. The cutting process in itself is very rapid, if the blank is pre-heated.

THE LATE DR. RÜMELIN.—Dr. Theodor Rümelin, who died only in his forty-fourth year, after a short illness at Münich last month, was an authority on hydraulic engineering and was prominently connected with the big Bavarian hydroelectric power scheme now being carried out. Born at Besigheim, in Württemberg, in 1877, he helped to work out the projects for the hydraulic installations at Mannheim, Ruhrort, Moosburg, Trostberg and the Walchensee. In 1913 he joined the staff of the Technical High School at Charlottenberg, and he remained there during the war, occupied on various classes of work. In May, 1918, he became director of the water utilisation company "Mittlere Isar." This company was taken over and enlarged by the Bavarian Government, and Rümelin had, before his death, given out several contracts and opened the small auxiliary hydraulic plant at Eisbach on the Isar, below Münich. During the last year he was editor of a new journal, *Wasserkraft*, and he is popularly known as author of several books on water-power plants and on the motion of water.

ALKALI HYDRIDES.—The hydrides of the alkali metals acquired a certain importance during the war as sources of hydrogen. They are compounds between the alkali metals and hydrogen, easily decomposable and about which not much is yet known. The information on them in text books is unreliable. They certainly are not metallic in character at all, but crystallised bodies resembling common salt. Theoretically they are very interesting because the hydrogen in them seems to be analogous to chlorine. Lithium hydride, LiH, for example, is formed by the reaction between lithium hydroxide and hydrogen: $LiOH + 2H = LiH + H_2O$, just as the hydroxide and hydrochloride acid yield the chloride: $LiOH + HCl = LiCl + H_2O$. This analogy between hydrogen and the halogens (fluorine, chlorine, bromine, iodine) has long been understood; in organic compounds chlorine, &c., readily replaces hydrogen. But the theoretical interest goes further. For this reason W. Nernst and K. Moers (*Zeitschrift für Elektrochemie*, August 1) electrolysed the fused lithium hydride. The metal lithium should go to the cathode and the hydrogen—which we generally expect to collect at the cathode—should travel to the anode in this instance. It did so; but the experiments are very difficult, and the quantitative relations are not quite settled yet. It is well known that hydrogen when liquefied looks like a snowy mass, not like a metal in the least. The assumption of an anodic hydrogen involves, however, the possibility of a dissociation of the neutral hydrogen molecule into a positive ion and a negative ion. When Van't Hoff years ago made such a suggestion as regards the oxygen molecule in order to explain auto-oxidation, he had most electro-chemists, including Nernst, against him. At present Nernst says that the hydrogen molecule is H_2E_2 (where E is the negative electron), and that it dissociates into a positive ion H· and a negative ion H^1 (or HE_2). Such dissociations have also been suggested by Sir J. J. Thomson.

"ENGINEERING" ILLUSTRATED PATENT RECORD.

SELECTED ABSTRACTS OF RECENT PUBLISHED SPECIFICATIONS UNDER THE ACTS OF 1907 AND 1919.

The number of views given in the Specification Drawings is stated in each case; where none is mentioned the Specification is not Illustrated.

Where inventions are communicated from abroad, the Names, &c., of the communicators are given in italics.

Copies of Specifications may be obtained at the Patent Office, Sales Branch, 25, Southampton Buildings, Chancery-lane, W.C., at the uniform price of 1s.

The date of the advertisement of the acceptance of a Complete Specification is, in each case, given after the abstract, unless the Patent has been sealed, when the word "Sealed" is appended.

Any person may, at any time within two months from the date of the advertisement of the acceptance of a Complete Specification, give notice at the Patent Office of opposition to the grant of a Patent on any of the grounds mentioned in the Acts.

AERONAUTICS.

148,698. E. E. Brown, London, and D. J. Mooney, London. Metal Construction for Aircraft. (5 *Figs.*) August 14, 1919.—The invention has relation to the construction of spars, girders, longerons, struts, stays and the like employed in the building up of the wings, fuselage and other parts of aircraft. According to the invention, the flanges at the top and bottom of the web each constitute a unitary body, and the web divides said body internally into triangular or substantially

Fig. 1.

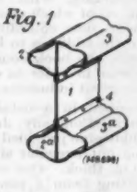
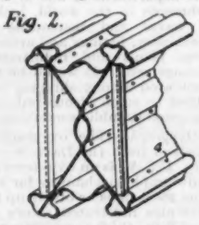


Fig. 2.



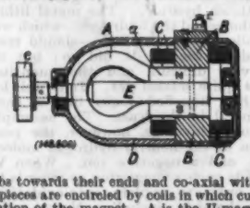
triangular spaces. The spars each comprise webs 1, having at the top and on both sides flanges 2, 3, and at the bottom and on both sides flanges 2a, 3a. The flanges 2, 3, as also the flanges 2a, 3a, are constituted of a single piece of metal, which is rolled to a triangular shape in cross-section. The web 1 is passed within the flanges 2, 3, and 2a, 3a, until its edges bear against the interior faces of the flanges, and is connected thereto by a line of rivets 4. The spar may be built up of two simple spars. (*Sealed.*)

ELECTRICAL APPARATUS.

148,647. Johnson and Phillips, Limited, London, and D. A. S. Porteous, Eltham. Electric Cables. (3 *Figs.*) May 23, 1919.—According to the invention, all the strands of a conductor are laid with a long lay in the same direction; each conductor is then insulated, so that there is the required thickness of insulation between the adjacent surfaces of the two conductors. A pair of conductors is then laid together in a machine, by means of detorsion or floating bobbins, the direction of the lay being also preferably the same as that of the separate strands, and, preferably, with approximately the same length of lay as the strands. The pair of conductors is then drawn through a series of circular dies, the diameters of which are progressively smaller, the pressure exerted causing the adjacent surfaces of the conductors to be flattened. The cable illustrated contains three-phase leads of twin-core conductors, and has been drawn through a series

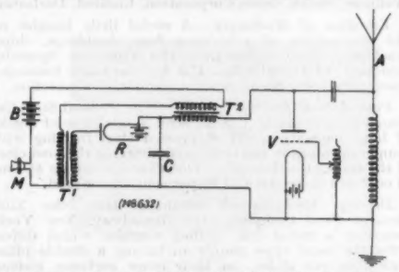
of circular dies, the diameters of which were progressively smaller. D is the insulation of circular cross-section covering the three phases of the twin cores, and E the lead sheathing which is applied after the cable has been passed through the dies. The circular section of each of the twin-core leads is changed by the applied pressure into an oval section. "Worming" F may be applied at requisite points within the insulating envelopes surrounding respectively each pair of conductors and the different pairs of the complete cable. Owing to the length of the lay, and the same direction of lay being used in each strand and also in each component of the system, comparatively small pressure is required to form the parts into the required shape, and owing to the absence of sharp corners characteristic of shaped conductors formed in the usual manner, there is a much flatter potential gradient around the perimeter of the conductors. (*Sealed.*)

148,600. S. G. Brown, F.R.S., London. Magneto-Electric Generators. (2 *Figs.*) March 26, 1919.—The invention relates to magneto-electric generators for use in lighting cars, and consists in arranging a permanent magnet of U-type to be spun around its longitudinal axis between stationary armature core pieces forming part of an annular core surrounding the



magnet limbs towards their ends and co-axial with the magnet, which core pieces are encircled by coils in which current is generated on rotation of the magnet. A is the U-magnet having its limbs turned to cylindrical form. B, B are the stationary armature core pieces. C, C are the coils wound upon the core pieces B. D is the outer casing of the generator, of an aluminium alloy. E is the central spindle mounted in the casing and carrying the magnet A, upon the outer end of the spindle being fitted a small friction wheel *e* for driving purposes. The casing D is rounded at the end receiving the middle portion of the magnet and is closed at the outer end by a cover, ball bearings at the end of the casing and the cover supporting the magnet spindle E, which passes through a hole in the centre of the magnet and between the limbs a. The magnet is firmly secured on the spindle by a cross-pin. The armature core pieces B are built up of soft iron stampings and project inwardly from the armature ring, the stampings building up the armature core being of annular form with deep notches between the core pieces, which receive the coils C. Two coils C are shown for each core-piece, the coils being bent into part circular form to lie closely within the armature ring. The coils are connected electrically to the terminals *c*. The two coils serve for alternating current, but three-phase or multi-phase current may be provided for. (*Sealed.*)

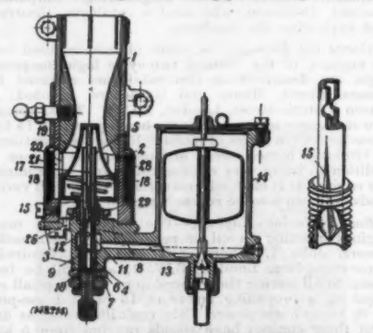
148,632. H. J. Round, London. Transmitters for Telephony. (2 *Figs.*) April 28, 1919.—The invention relates to improvements in telephone transmitters of the type employing thermionic generators. According to the invention, means are provided whereby the voice itself causes both direct and alternating current to be fed to a thermionic generator, the direct current, starting with the voice and stopping with the voice, causes continuous waves to be generated while the alternating current causes the amplitude of these waves to be varied. M is a microphone connected in series with a battery B and the primaries of two transformers T1 and T2. The secondary of T1 is connected through a rectifying valve R to a condenser C, one side of which is connected to the filament of a thermionic generator V, while the other side is connected through the secondary of T2 to the anode of the generator V connected to an aerial A. It will be seen that since there is no source of potential such as the usual battery in the anode filament circuit



of V, there will be no generation of oscillations by V until speech is commenced, when direct current will be fed to the anode filament circuit from the charge in condenser C, due to the transformer T1 and the rectifier R. The valve will then generate continuous waves the amplitude of which will be varied according to the speech by the alternating currents fed to the valve by the transformer T2, and the envelope of the oscillations will correspond to the alternating current wave, and the speech will be reproduced at the receiving end without distortion. If the windings of T1 and T2 are such that a fairly large part of the energy goes to the production of the direct current and only a smaller part to the production of the alternating current, a rapid rise of direct current potential on the condenser takes place, as soon as speech starts. In order, however, to prevent this potential from rising to more than a definite value, a limiting device may be employed which, by limiting the potential in C speeds up the dying away when the speech stops. (*Sealed.*)

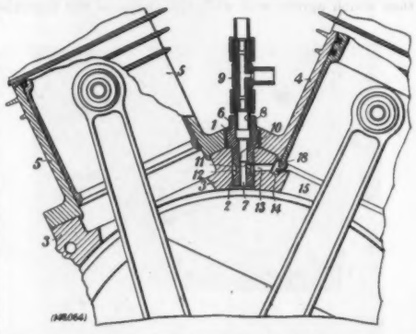
GAS ENGINES, PRODUCERS, HOLDERS, &c.

148,714. G. H. Strain, Malvern. Carburettors. (4 *Figs.*) November 13, 1919.—According to the invention, in a carburettor there is combined with a chamber having two inlets for air, one communicating with the jet and the other communicating with the delivery point of the mixture of petrol and air formed with the air supplied by the first-mentioned inlet and means to adjust the second inlet, a jet comprising a tube mounted on the bottom of said chamber and communicating with the petrol supply, a jet sleeve surrounding said jet and projecting beyond it, a jet tube projecting into the upper end of the sleeve and having an orifice connecting it therewith, a jet needle carried on the end of said tube and projecting into the jet, an adjustable carrier for the jet tube, and a partition separating the jet sleeve and one air inlet from the adjustable air inlet to the chamber. In a cylinder 1, which is connected at its upper end to the engine induction pipe, is arranged a sleeve 2,



and the cylinder is closed at its lower end by a fitting 3. Within the lower end of the fitting is screwed a jet sleeve 4, which projects up into the cylinder as shown at 5, and is locked in place by a lock-nut 6 and washer 7. Within the jet sleeve is screwed the tube 8 constituting the jet. The said tube 8 has holes 9, communicating with a surrounding annular chamber 10 within the jet sleeve 4, and this chamber communicates by holes 11 with a chamber 12 in the fitting 3. The chamber 12 communicates by the passage 13 with the float chamber 14. The jet needle 15 extends into the open end of the jet 8, and consists of a cylindrical rod with the lower end of slightly reduced diameter, and having a channel cut in it of angular shape, of greatest area at the point of the needle and reducing to nothing at a distance up. The needle 15 is carried on the end of a jet tube 17, which extends downward within the upper end 5 of the jet sleeve 4, and has orifices 18 communicating therewith. The jet tube 17 is mounted on a carrier 19, which fits against the inside of the sleeve or piston 2 and surrounds the upper end of the jet sleeve 5. Ports 20 are cut in the sleeve 2, and corresponding ports 21 in the cylinder wall, which latter are covered with gauze carried on an outer sleeve surrounding the lower part of the cylinder 1. A stud is screwed into the sleeve 2 for moving the latter, and it is guided in a slot in the sleeve. An air inlet 26 covered with gauze is provided at the bottom of the cylinder, opening into the space enclosed by the jet tube carrier 19, and it will be seen that the air supplied through this inlet is separated from the air supplied through the ports 20 and 21. A spring 28 bears against the underside of the jet tube carrier 19, and a washer pressing on the gland packing 29. A lock-nut and washer are provided to lock the jet 8 in position. (*Sealed.*)

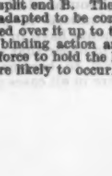
148,064. The Birmingham Small Arms Company, Limited, Birmingham, and H. Poole, Studley. Internal-Combustion Engines. (2 *Figs.*) September 2, 1919.—The invention relates to improvements in the lubrication of internal-combustion engines, and refers more particularly to the lubrication of twin cylinders such as are mounted on the crank-case and disposed in angular relation one to the other. The invention consists in the employment of a fitting which is adapted to be mounted in a hole formed in the upper side of the crank-case, intermediate of the front and rear cylinders, the said fitting being provided with a longitudinal hole or oil passage, and is adapted at its upper end to be connected to the oil feed pipe. In the lower stem part of the said fitting are formed downwardly-inclined radially-disposed outlets from the central hole or passage therein, the said outlets being arranged to align with the horizontal hole formed in the crank-case and leading to an annular groove formed in the upper face of the crank-case around the opening over which the front cylinder is mounted, the said annular groove being adapted to form a sump into which the diverted oil collects. The lower end of the piston is lip-shaped and adapted to dip into the sump at the end of its downward stroke, and thus pick up a portion of the oil in the sump, which is carried on to the inner wall of the cylinder during its upward or return stroke. The fitting 1 is provided at its lower end with a screwed stem part 2, which enters a tapped hole formed in the upper side of the crank-case 3 intermediate of the front and rear cylinders 4 and 5, and its upper end 6 is hexagonal in shape to permit of it being assembled in its position by means of a spanner



Through the fitting is formed a longitudinal hole 7, into the end of which the nozzle end 8 of the oil feed pipe union or coupling 9 is secured. The longitudinal hole or passage 7 in the lower stem part of the fitting 1 is of a smaller diameter than the upper part of the said hole, thus forming a shoulder 10, at which point one or more downwardly-inclined radial holes 11 are provided, which enter a circumferential groove 12 formed in the outer diameter of the screwed stem part of the fitting. In the crank-case 3 is formed a horizontal passage 13 which aligns with the circumferential groove 12 in the stem of the fitting when the latter is in its assembled position, the said passage leading to the oil sump of the front cylinder 4. The sump may be formed by providing an annular groove or recess 14 around the opening 15 in the crank-case over which the front cylinder 4 is fitted, the inner wall of the said annular recess being preferably inwardly inclined. The lower end of the front piston is provided with a lip formation in the outer face of which is formed a circumferential groove 18, while its inner face may be tapered inward at an angle corresponding to the inclined inner wall of the annular groove 14 in the crank-case which constitutes the oil sump. A portion of the oil, in its passage from the oil feed pipe through the fitting 1 to the crank-case 3, is arrested by the shoulder 10 in the hollow stem part 2 of the fitting 1, and is diverted through the radial passages 11 to the annular chamber formed by the circumferential groove 12 on the stem part of the fitting 1, from which it passes through the hole or communicating passage 13 formed in the crank-case 3 to the oil sump 14, and the lip of the front piston being arranged to dip into the said sump, oil is thereby conveyed to the front cylinder 4. (*Sealed.*)

MACHINE AND OTHER TOOLS, SHAFTING, &c.

148,102. G. L. Norman, Guildford, and A. Drummond, Guildford. Change-Speed Wheels of Lathes. (2 *Figs.*) February 2, 1920.—The invention relates to a stud or spigot for the change-speed wheels of lathes. According to the invention, the stud or spigot is formed with a split end and the head which retains the gear wheel is bored with a central hole and fits upon the split end of the stud, the split end binding against the walls of the hole in the head so as to hold the latter in place. A is the spigot provided with the screwed end *a* by which it is secured



in place, the screwed end extending from the collar a^1, which is flattened at the sides to allow of the use of a spanner. B is the split end of the stud, of somewhat reduced diameter to form the shoulder a^2. C is a knurled head formed with an axial hole adapted to fit over the split end B. The split end B is rounded at its extremity and is adapted to be compressed by the head C when the latter is pushed over it up to the shoulder a^2, so that the split end exerts a binding action and retains the head in position with sufficient force to hold the head C in place against such side pressures as are likely to occur. (*Sealed.*)